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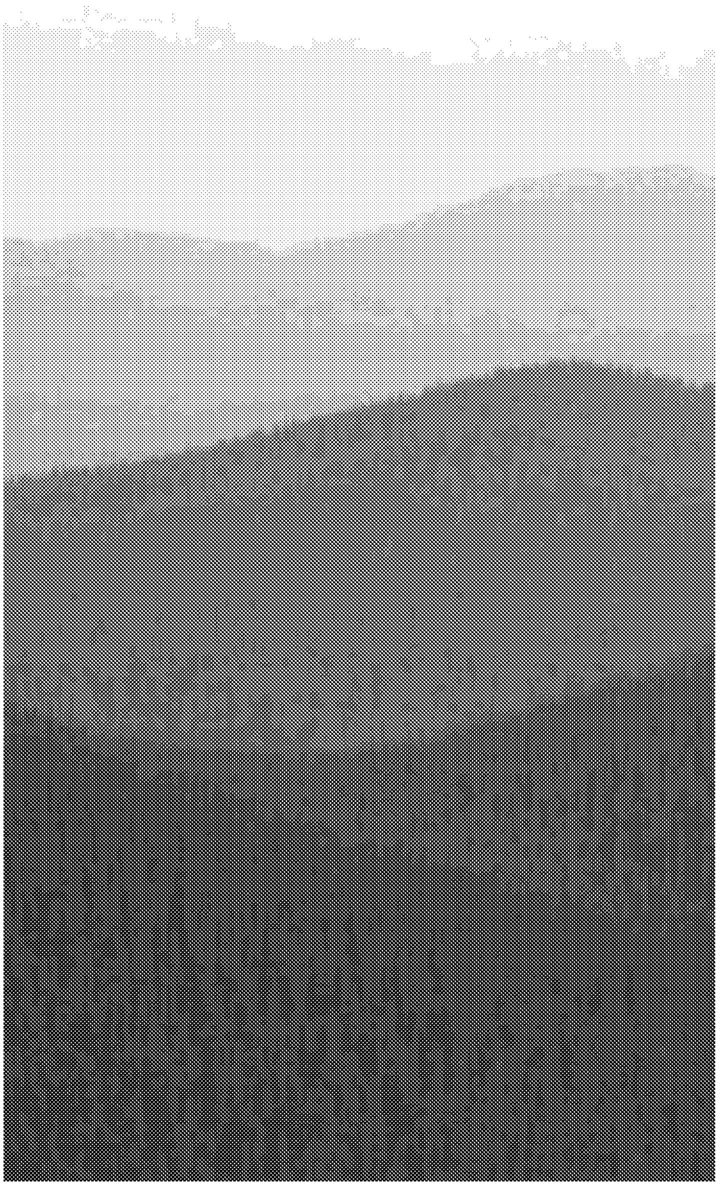

2002 Fire Emission Inventory for the WRAP Region – Phase II

Western Governors Association/Western Regional Air Partnership

Project No. 178-6
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EXECUTIVE SUMMARY

The Fire Emissions Joint Forum (FEJF) of the Western Regional Air Partnership (WRAP) has completed an air emission inventory for fire in 14 of the 15 states in the WRAP region. (Hawaii is not in the inventory.) The inventory includes emission estimates and activity data for wildfire, prescribed fire, wildland fire use (WFU), agricultural burning, and non-federal prescribed rangeland (NF rangeland) burning for the calendar year 2002. The FEJF collected fire activity data from federal, tribal, and state agencies; arrived at data quality objectives; culled data from the database that did not meet the data quality objectives; allocated summary data to realistic fire events where necessary; devised emission calculation routines; estimated emissions for all fire events; and published an emission inventory database and dispersion model-ready digital files.

The purpose of the fire emission inventories is to further the WRAP's charge of supporting member states' and Tribes' Regional Haze State Implementation Plans and Tribal Implementation Plans. Along with emission inventories from other types of sources, the 2002 fire emission inventories will be used by the Emissions and Air Quality Modeling Forums of the WRAP to execute, evaluate, and enhance the performance of the WRAP-wide air quality dispersion models. Also, the 2002 fire emission inventories will be used to support the WRAP's, States', and Tribes' efforts to allocate regional haze impacts to specific sources.

Building the emission inventory involved many technical steps shaped by extensive stakeholder and expert discussion. Many of the techniques utilized for this emission inventory are based on the WRAP technical report entitled "1996 Fire Emission Inventory." Driven by the WRAP's targets for a highly resolved (temporally and spatially) dispersion model, the FEJF produced an *event-based* emission inventory, placing all fire emissions at coordinate locations on specific days. Federal and state records of individual fire events were collected. For agricultural and non-federal rangeland burning, county level data on a monthly basis was collected and allocated to the coordinate level on a daily basis for jurisdictions where event level data was not available. In general, burning activity data was not available directly from tribal agencies. Federal land manager (especially Department of Interior – Bureau of Indian Affairs) data included in the federal databases as well as state data may include burning in Indian Country. Quality Control Packets where sent to states, Tribes, and federal land management agencies (FLMs) to solicit corrections to the 2002 activity data for wildland burning and agricultural burning.

Activity records were checked for completeness for fire size, fuel loading, date, and location. Activity records deemed incomplete and therefore not useable in an emission calculation were culled from the database (and retained in a companion database for documentation purposes). Fuel loading and emission factor tables along with diurnal consumption and plume profiles were developed from the literature, expert and professional judgment, and stakeholder input. Spreadsheet and geographic information system software was used to store the data, perform data augmentation and quality control functions, calculate emissions, and produce the strictly formatted National Emission Inventory Format (NIF) 3.0 and SMOKE/IDA text export files of the inventories. The methods developed for this study may be refined and utilized for future air emissions analyses. Table 1 presents an abbreviated summary of the 2002 wildfire, prescribed fire, and WFU inventories.

Limitations of this emission inventory include the omission of fire events (e.g., tribal burning, in general, not accounted for in non-tribal data sets and individual fire activity records deemed to be incomplete) and variable data quality due to the variety of data sources used. Furthermore, estimating emissions from vegetative burning involves considerable scientific uncertainty.

Table 1: Executive Summary of Fire Activity and Emissions from Wildfires, Prescribed Fires, Wildland Fire Use, Agricultural Burning, and Non-Federal Prescribed Rangeland Burning in 2002

Source	Fire Days	Acres Burned	Tons Fuel Consumed	Tons $PM_{2.5}$ Emitted
Wildfire	5,835	5,276,485	123,642,024	1,489,886
WFU	369	201,548	6,763,940	81,505
Prescribed	16,445	649,044	7,195,489	71,420
Agricultural	105,991	2,163,478	6,061,792	34,578
NF Rangeland	4128	1,042,003	1,823,507	15,454
Total	132,768	9,332,559	145,486,752	1,692,845

SECTION 1

INTRODUCTION

This documentation is a summary of the activity data, calculations, and results of the historical fire emission inventory for 2002 prepared for the Emissions Task Team (ETT) of the FEJF. For consistency, many of the technical methods used to build the 2002 inventory are intentionally the same as the WRAP 1996 fire emission inventory. Technical improvements were made by the FEJF to this 2002 process including refining the daily fire spread algorithm and updating plume profile parameters. Details of the 2002 fire activity data collection and processing are bulleted for each data set received in Appendix A.

Significant improvements to the fire emission inventories have been made on the activity data side. For example, the results of the wildfire, prescribed burning, and agricultural burning quality control review efforts have been incorporated in the Phase II activity data. Also, for the first time, estimates of non-federal rangeland burning activity and emissions are included in the WRAP's 2002 fire inventory.

1.1 Basic Concepts of the 2002 WRAP Fire Emission Inventory

The FEJF inventoried fire emissions for calendar year 2002 for the states in the continental WRAP region plus Alaska. The term "fire" refers inclusively to wildfire, wildland fire use (WFU, formerly prescribed natural fire), prescribed fire, agricultural burning, and non-federal prescribed rangeland burning. The term "wildland fire" refers only to wildfire, WFU, and prescribed fire which have many data sources and calculation parameters in common. This emission inventory was based on data collected by state and federal agencies. Agricultural burning was inventoried based on a combination of event-level and monthly summary data submitted to represent 2002. State-level estimates of activity of non-federal prescribed rangeland burning were supplied by the ETT and allocated to events for modeling.

The WRAP Air Quality Modeling and Emissions Forums provided the FEJF with specific data resolution requirements for the fire emission inventory. For spatial resolution, each fire event needed a specific latitude and longitude in order to satisfy the spatial resolution goal of one minute of latitude and longitude. For temporal resolution, hourly emission estimates for each fire event were required.

Estimating emissions from fire events involves considerable scientific uncertainty. Historic data are of varying quality and for some areas unavailable. Activity records were not ground-truthed and, other than quality control steps described in this report, were generally accepted "as is." Parameters such as the vegetation type of a burn, the vegetation-specific fuel loading, pollutant-specific emission factors, and combustion efficiencies, to name a few, all have uncertainties associated with them which may influence emission estimates and regional modeling results.

The efforts of the ETT were dedicated to using professional judgment to select the best available or most representative parameters or methods to estimate emissions. However, other parameters and methods could have been chosen and could also be considered "reasonable" for estimating emissions from fire.

The specifications required by the Emissions and Air Quality Modeling Forums combined with the limitations of existing data and emission estimation methods shaped the emission inventory development. Fire, traditionally considered an "area" source, is treated as a "point" source in the WRAP's regional dispersion model. Therefore, fire emissions were placed at a latitude/longitude coordinate location for each day. From the daily and spatially resolved emission inventory, hourly consumption and plume rise were estimated.

The 2002 emission inventory was made available to the WRAP Modeling Forum digitally as database files and text files formatted for input to the Sparse Matrix Operator Kernel Emissions (SMOKE) Modeling System (PTINV, PTDAY, and PTHOUR files in IDA format). Also under this contract, the National Emission Inventory Format (NIF) 3.0 for point sources was adapted to accommodate this emission inventory. NIF 3.0 formatted text files were provided to the WRAP.

1.2 Fire Emission Inventory Phases

The FEJF has identified a number of phases of emission inventory development to supply the WRAP with appropriate emission inventories for its regional haze dispersion modeling efforts. These phases are:

- Phase I – Modeling Evaluation Emission Inventory (Phase I EI): Actual 2002 wildland fire and prescribed fire emission inventories and use of the 2018 Agricultural Burning Base Smoke Management Program emission inventory as a placeholder. Primary use of the Phase I inventories is to verify and enhance dispersion model performance and to test geographic source apportionment (modeling estimates of contribution at each Class I area from each upwind source jurisdiction).
- Phase II – Initial Modeling Apportionment Emission Inventory (Phase II EI): Actual 2002 wildland fire and prescribed fire emissions (split into natural and anthropogenic events) emission inventories, actual 2002 agricultural burning emission inventory, and estimated 2002 non-federal rangeland burning. Primary use of the Phase II inventories is to complete the WRAP's geographic source apportionment for the Attribution of Haze Project (per the WRAP's Strategic Plan 2003 – 2008).
- Phase III – Planning Baseline Period Emission Inventory (Phase III EI): Emission inventories for wildland fire, prescribed fire, and agricultural burning that are based on 2000 through 2004 (or longer) fire activity data that is assessed to be representative of regional haze baseline period. The emission inventory format used for Phase II will be used for Phase III for consistency.

- Phase IV – Planning 2018 Projection Year Emission Inventory (Phase IV EI): Projected emission inventories for wildland fire, prescribed fire, and agricultural burning. Projections will be based on predictable variables and may be in the form of emission scenarios or ranges of emissions. The emission inventory format used for the Phase III baseline planning inventory will be used for Phase IV for consistency.

The fire emission inventories delivered with and described in this document are the Phase II emission inventories. Calculation methods and data quality standards were devised with the FEJF's stated objectives for the Phase II inventories in mind. The FEJF emission inventory reflected consistent methods and specific fire event data. Data quality standards were set for the historic activity data collected. Consistent calculation methods and calculation parameters (such as literature-based fuel loadings) were implemented.

1.3 Comments & Revisions Incorporated in the Final Report

The draft report for this project was distributed in an e-mail sent on April 4, 2004, by the FEJF co-chairs to the Emissions Task Team and other interested members of the FEJF. Reviewers were given two weeks to provide comments on the draft report. Seven comments were received. Commenters included:

- Neva Sotolongo, California Air Resources Board
- Lee Alter, Western Regional Air Partnership
- Doug G. Fox, Ph.D., Cooperative Institute for Research in the Atmosphere, Colorado State University
- Lisa Bye, US DOI Bureau of Land Management, New Mexico
- Christi Gordon, USDA Forest Service, Southwest Region
- Darla Potter, Wyoming Department of Environmental Quality, Air Quality Division
- Ron King, Alaska Department of Environmental Conservation

Comments were primarily editorial in nature were integrated into the document. One commenter requested a comparison of the Phase II EI with the CEIDARS database for California. Such a comparison is beyond the scope of this project, but the Phase II data is certainly available for use by the commenting agency to perform its own comparison.

1.4 Partners and Contributors in the Project

Air Sciences acknowledges the contributors to the development of the Phase II EI database and this report. Contributors include:

- Members of the Emissions Task Team of the FEJF.
- Members of the FEJF.
- Peter Lahm, USDA Forest Service, former co-chair of the FEJF.
- Darla Potter, Wyoming DEQ, co-chair of the FEJF.
- Mark Fitch, USDA Forest Service, co-chair of the FEJF.
- Tom Moore, Western Regional Air Partnership.
- Pat Shaver, USDA Natural Resources Conservation Service.
- Staff of the National Tribal Environmental Council (NTEC).
- Participants in the BETA testing group for the Agricultural Burning and Wildland Burning Quality Control Binders, including:
    - Peter Lahm, USDA Forest Service
    - Mark Fitch, USDA Forest Service
    - Darla Potter, WY DEQ
    - Mike Ziolko, Oregon Department of Forestry
    - Jim Russel, USDA Forest Service
    - Paul Schlobohm, US DOI Bureau of Land Management
    - Aaron Worstel, US DOI National Park Service
    - Cathy Messerschmitt (formerly with NTEC)
    - Neva Sotolongo, California ARB
- State and tribal air quality agency personnel that provided QC review on the fire emissions inventory data.
- State and federal land management agency personnel that provided QC review on the fire emissions inventory data.

SECTION 2

THE 2002 WILDLAND FIRE EMISSION INVENTORY

The ETT established a number of fire event data objectives that were used to identify and utilize wildfire, WFU, and prescribed burning event data suitable for the 2002 fire emission inventory. Each individual entry in the "raw" fire activity database was analyzed to determine if all of the fire event data objectives were met in order for the record to be included in the fire emission inventory. For wildland fire, all activity data collected was at the *event* level, and summary data was rejected. The data objectives were:

- A specific location for each fire event.
- A specific calendar day in 2002 for each fire event.
- A specific size for each fire event.
- Sufficient information to assign a fuel loading for each fire event.

The wildfire, prescribed burning, and WFU emission inventories were developed with parallel data gathering and emission calculation techniques. The same basic inventory process was utilized with a few specific variations implemented. A summary of the technical methods follows.

The wildland fire use events were originally classified as wildfire events in the database. They were processed as wildfire events and were identified as WFU events and treated separately from wildfire only after spatial and temporal allocation, fuel loading and emission calculations, and plume characterization had been completed. Therefore, in this report, the term wildfire includes WFU data unless otherwise specified.

2.1 Activity Data

Wildfire activity data including WFU data were collected by the FEJF using a tiered process. Wildfires greater than 10 acres in size were sought, but any fire record collected was used. Detailed activity data with sufficient spatial and temporal resolution were contained in the National Interagency Fire Center's (NIFC) daily National Situation Report publication and ICS-209 wildfire forms. The National Situation Report database and ICS-209 databases were merged. Procedures were implemented to avoid including duplicate records in the merged data set.

In a companion effort, 2002 records from the Department of the Interior's Wildland Fire Management Data and the Department of Agriculture's Forest Service National Interagency Fire Management Integrated Database were appended to form an independent "federal database" of fire events. Fire events in the National Situation Report/ICS-209 database were then paired with fire events in the "federal database." The National Situation Report/ICS-209 database was supplemented on a record-by-record basis with location, fire size, and fuel loading information from the "federal database" where necessary.

For prescribed fire activity, the FEJF set no de minimus activity level for burns. Air Sciences Inc., under the authority of the FEJF, made requests of air quality and/or department of forestry officials of each state in the WRAP region to provide wildland prescribed fire activity within their jurisdiction for 2002. Individual fire records were needed to satisfy precise temporal, spatial, and activity criteria for WRAP modeling purposes. Therefore, the FEJF requested:

1. Any information that could be used to ascertain a prescribed fire's location (i.e., legal location, latitude/longitude coordinates, and county).
2. Timing information (burn date or season) and/or fire duration.
3. Such fuels information as vegetation type, acres burned, tons burned, and burn type (piles or broadcast).

2002 prescribed fire information was received from each of the WRAP states. Generally, information received from interagency or state-facilitated smoke management programs encompassed prescribed fire data for multiple federal and state land management jurisdictions. DOI-1202 (Department of Interior), NIFPORS (National Fire Plan Operation Reporting System), and FASTRACS (Fuel Analysis, Smoke Tracking, and Report Access Computer System) data were received independently from federal agencies. State data not closely matching federal prescribed fire totals reported by NIFC were augmented with prescribed fire records from the federal databases. Fire records having sufficient spatial, temporal, and activity components were formatted into a single region-wide prescribed fire activity inventory.

See Appendix A for a more detailed description of data gathering methods, results, and assumptions for each state and agency.

2.1.1 Geo-Referencing Fire Location by Township/Range/Section and County

Many of the records in the prescribed fire activity data set did not have latitude and longitude coordinates but did have location information in the form of a Township, Range and Section (TRS) or county identifier.

A geographic information system (GIS) algorithm was developed to convert, or geo-reference, TRS codes to a latitude and longitude coordinate pair using the National Atlas Public Land Survey System (PLSS) map of Township and Range. Meridian was not available in the raw activity data and was assigned to each fire based on state name. The fundamental steps of the TRS geo-referencing were:

1. Convert the fire record's PLSS information to Meridian Township Range (MTR) and Section code.

2. Locate that MTR on the PLSS map.
3. Within the MTR, estimate the location of the center of the Section.
4. Identify the latitude and longitude of this point.
5. Record the estimated geographic coordinates in the activity record.

In addition to this GIS-based method, legal location was geo-referenced using the "Wefald" TRS-conversion software (TRSfile v1.2, available at: http://members.cox.net/azregion/trsfile/trsfile.htm). This software attempts to geo-reference TRS locations that are not technically part of the PLSS (for instance land grants and tribal lands) and hence do not appear in the official PLSS map relied upon in the GIS-based method. Legal description and state name for all wildland fires were exported from the activity data to a comma-separated file specified by the Wefald software. The Wefald software was run, and the output file with latitude and longitude was imported back to the emission inventory.

Thirdly, fires were geo-referenced by county identifier. If the county and state name matched the National Atlas county layer, the centroid coordinates of the county shape were written to the activity record.

In lieu of latitude and longitude coordinates being supplied in the raw data, fire events were located by (1) GIS-based TRS geo-referencing, (2) Wefald-based TRS geo-referencing, and, lastly, (3) county centroid. After geo-referencing the wildland fire data, 17 fire records, corresponding to 16 individual prescribed fire events, had locations that were outside of the WRAP region. These records were dropped from the Phase II EI database but retained in a separate file for documentation purposes.

2.1.2 GIS-Based NFDRS Fuel Loading Assignment

Fire events in the wildfire and prescribed burning activity databases that did not contain fuel type in the source data were assigned a fuel model using GIS techniques. The fire's location was plotted on the National Fire Danger Rating System (NFDRS) fuel model map, and the corresponding fuel model code was recorded to the activity record. This procedure was applied to each record in the activity database. The specific steps are:

1. A mappable point for the fire is created from its latitude and longitude.
   (Activity records are geo-referenced based on their latitude and longitude.)
2. The fire point is converted to the different map projection of the NFDRS map.
   (Geographic coordinates are projected to Lambert Equal Area Azimuthal.)
3. The fire point is "dropped" on the NFDRS Fuel Model map.
   (The intersected grid cell is identified.)

4. The fuel model at that point, as a coded number, is identified.

   (Numeric fuel model attribute value is extracted from the grid cell.)

5. The numeric fuel model name is saved to the fire activity record.

   (Numeric fuel model code is written to a newly created field in the activity database.)

6. The numeric code is translated to the standard NFDRS Fuel Model letter code.

   (For all records, the fuel letter is looked up by fuel number and saved in a new field.)

Records receiving the "ag" designation were presumed to occur in a grassland environment and assigned the same fuel loading as NFDRS Fuel Model C, pine-grass savanna. Activity records intersecting "water" and "barren" did not receive a fuel model assignment from this process.

2.1.3 Final Activity Data Quality Control

The wildland fire activity data set was quality-controlled using geographic information science. Logical inconsistencies were identified and recorded in the activity data set. Certain flaws were considered "fatal" and resulted in the record remaining in the activity data set, but being "dropped" from the emission inventory. Only records with a valid start and end date, location (latitude and longitude coordinate), non-zero fire size in acres, and calculable fuel loading in tons were carried over to the final emission inventory. The wildfire activity data set was supplied with 3,243 records. In total, 86 activity records (2.7 percent) totaling 18,447 acres were dropped due to insufficient or inconsistent data, and 3,157 wildfire records were carried over to the final emission inventory. This corresponds to 1,820 individual fire events (many individual fire events were multi-day events). The prescribed fire activity data set was supplied with 10,963 records. In total, 963 activity records (8.8 percent) totaling 51,723 acres were dropped due to insufficient or inconsistent data, and 10,000 prescribed fire events were carried over to the final emission inventory. The majority of prescribed fire records (~890) were dropped due to an invalid location input in term of TRS coordinates that could not be filled in the absence of a county code or name.

2.1.4 Wildland Fire Use

Wildland Fire Use (WFU) was included as a unique fire type in this emission inventory. WFU events were originally categorized as wildfires and were treated as wildfires for spatial and temporal allocation as well as emission calculations. Therefore, some of the tables and charts in this report categorize data only as wildfire and prescribed fire. In these cases, WFU is combined with wildfire.

Table 2 summarizes the fire events classified as WFU. The majority of WFU fire activity in the 2002 emission inventory occurred in Alaska: 79 percent of the acreage, 89 percent of the fuel consumed, and 89 percent of the $PM_{2.5}$ emissions. Other states with reported or allocated WFU activity included California, Colorado, Idaho, Montana, New Mexico, Utah, and Wyoming.

Information on WFU events was found in two data sources:

1. The DOI-1202 data contain a subset of data with a numerical code indicating WFU for the FWS, NPS, BLM, and BIA lands.
2. NIFMID data contains a subset of data that contained the WFU events for the U.S. Forest Service in 2002.

All the WFU records from both the DOI-1202 and the NIFMID data sets were extracted and compared to the wildland fire activity data. This comparison was based on (1) fire name, (2) fire date, and (3) fire acreage. The results of this comparison indicated that the majority of the WFU activity in the DOI-1202 and the NIFMID databases were indeed included in the Phase I EI wildfire data. All WFU records were assigned a unique label to distinguish these events from wildfire events in the database.

Table 2: Summary of Wildland Fire Use Data in Phase I EI

Source Data	WFU Acres	In Phase I EI (acres)	In Phase I EI (%)
DOI 1202	168,055	167,708	99.7
NIFMID	36,208	33,934	93.7
Total	204,263	201,642	98.7

Some of these discrepancies stem from the fact that the Phase I EI includes fire records ≥10 acres only, while the DOI-1202 and NIFMID databases include all fire sizes. Moreover, in some cases there were minor discrepancies between the acres included in the Phase I EI and the other data set for the same fire event. For the Phase I EI, the records in the original database were retained, and the discrepancy between the DOI 1202/NIFMID records and the Phase I EI records was not resolved (approximately 2,600 acres).

As a result of the large fire refinements and the wildland fire quality control process (each described later in this section), WFU activity was reduced by approximately 100 additional acres in the final Phase II EI.

2.1.5 Natural and Anthropogenic Assignments (For All Fire Sources)

Each wildfire, prescribed burn, agricultural burn, and non-federal rangeland burn in the WRAP Phase II EI for fire was flagged as natural or anthropogenic in origin. This was done using the following approaches, based on the WRAP Fire Emissions Joint Forum's *2001 WRAP Policy for Categorizing Fire Emissions* and *Guidance for Classifying Natural Versus Anthropogenic Fire Emissions* (under development). Further approaches for categorizing natural and anthropogenic fires may be developed by the FEJF for subsequent Phase III and IV emission inventories.

The FEJF database for fire was amended with a field to flag each fire event as natural or anthropogenic. Also, the Source Classification Code (SCC) assignment performed in the database was refined to assign custom SCCs, which accommodate specific fire types discussed in this document. Each SCC present in the emission inventory identifies each event as either natural or anthropogenic. The SCC stays with the fire event in the SMOKE model-ready files delivered to the WRAP Regional Modeling Center (RMC) as well as in the NIF 3.0 files. These SCCs are defined in Table 3.

Table 3: SCCs and Their Fire Type and Natural/Anthropogenic Classification.

SCC	Fire Type	Natural or Anthropogenic
2810001000	Wildfire	Natural
2810001001	WFU	Natural
2810001002	WFU	Anthropogenic
2801500000	Agricultural	Anthropogenic
2801500001	Agricultural (Native American)	Natural
2810015000	Prescribed	Anthropogenic
2810015001	Prescribed	Natural
2810016000	Non-Federal Rangeland	Anthropogenic
2810016001	Non-Federal Rangeland	Natural

Wildfire

All wildfire was categorized as natural. The SCC for wildfire (2810001000) was considered exclusively natural.

Wildland Fire Use

All Wildland Fire Use (WFU) incidents identified in the Phase II EI were categorized as natural. A custom SCC of 2810001001 was used to identify WFU natural events. It is helpful to note that by definition WFU is a distinct fire source from both wildfire and prescribed burning. That is, a WFU incident cannot also be considered wildfire or prescribed burning. In the event that entities within the WRAP modify the categorization of WFU incidents to include anthropogenic events, a custom SCC of 2810001002 has been reserved as a placeholder..

Agricultural Fire

All agricultural burning in the Phase II EI was categorized as anthropogenic and given the standard SCC of 2801500000.

The *2001 WRAP Policy for Categorizing Fire Emissions* states that "vegetative burning conducted by Native Americans for traditional, religious, and ceremonial purposes" is considered natural and all other vegetative burning conducted by Native Americans is classified as "prescribed," with agricultural burning fitting the definition of prescribed fire. Some agricultural fire events in the

Phase II EI fell within the exterior boundaries of tribal lands, but the Phase II EI lacked an indication of "traditional, religious, or ceremonial" purpose. Therefore agricultural events falling on tribal lands were still categorized as anthropogenic. A custom SCC of 2801500001 will be used in the future to classify agricultural burning determined to be of a natural origin.

Prescribed Fire

Prescribed fire was categorized as either natural or anthropogenic. The standard SCC of 2810015000 represented anthropogenic prescribed burns, and a custom SCC of 2810015001 represented natural burns.

Because the raw activity data for prescribed fire do not include a natural or anthropogenic identifier, nor do the raw data contain burning objective information (e.g., "maintenance" or "restoration"), the ETT elected to base the categorization of prescribed fire as natural or anthropogenic on the National Fire Danger Rating System (NFDRS) fuel model for each incident (Table 4). An NFDRS fuel model exists for each wildfire and prescribed burn in the Phase II EI. Each incident in the Phase II EI had only one NFDRS assignment based on the observed fuel model reported in the activity database (preferred) or was assigned by overlaying the fire location on the national NFDRS fuel model map using GIS (see the WRAP 1996 Fire Emission Inventory documentation). The NFDRS categorizations as natural or anthropogenic were based on examining the text descriptions of the fuel models and identifying the buildup of "above normal" fuel loadings (for example, the short-needle conifer models G and H as anthropogenic and natural, respectively).

Regardless of NFDRS fuel model, all piled prescribed burns were categorized as anthropogenic.

Table 4: Prescribed Fire NFDRS Fuel Model Categorization as Natural or Anthropogenic

NFDRS Fuel Model	Categorization	Short Vegetation Description
A	Natural	Western annual grasslands
B	Anthropogenic	Tall dense older brush
C	Natural	Open pine with grass understory
D	Natural	Southeast fuel types
E	Natural	Hardwood after leaf fall
F	Natural	Mature closed Chamise with Oakbrush
G	Anthropogenic	Dense Conifer with heavy downed duff
H	Natural	Short-needled Conifer with thin litter
I	Anthropogenic	Clearcut Conifer Slash <6"
J	Anthropogenic	Clearcut heavily thinned Conifer Slash <6"
K	Anthropogenic	Light conifer slash partial cuts
L	Natural	Western perennial grasslands
N	Natural	Southeast fuel types
O	Natural	Southeast fuel types
P	Natural	Southeast fuel types
Q	Natural	Upland Alaska Black Spruce
R	Natural	Hardwoods after leafout
S	Natural	Alpine Tundra and grass
T	Natural	Sagebrush and grasslands
U	Anthropogenic	Closed Western Long-Needled Pine
Piles	*Anthropogenic*	*Piled activity fuels*

Non-Federal Prescribed Rangeland Burning

The ETT elected to assign all non-federal rangeland burning events in the Phase II EI as natural. This decision was deemed to be consistent with the intent of the WRAP's categorization policy. The decision is also based on the facts that fuel loading assignments for non-federal rangeland burning events are assigned generally (i.e., there are no event-specific fuel loading data for non-federal rangeland fire events in the inventory) and fuel loading is low (1.75 tons of fuel per acre). All prescribed rangeland burning events on non-federal lands in the Phase II EI were categorized as natural and given a custom SCC of 2810016001. The SCC 281001600 will be reserved for anthropogenic non-federal rangeland burning in case the categorization technique changes for the FEJF's Phase II and Phase IV emission inventory projects.

The ETT also acknowledged the following:

- Non-federal rangeland burning should be regarded similarly to wildland prescribed burning in that efforts to control emissions should be implemented when and where possible.

- The FEJF's fire tracking system (to be developed) should accommodate data that indicates the stated objective(s) of non-federal rangeland burning events.
- The categorization technique for non-federal rangeland burning may be modified for future inventories.

2.2 Fuel Loading and Emission Factors

In the event that fire event-specific fuel loading values were not contained in the database record, fuel loading in tons per acre for the wildfire inventory were assigned using the NFDRS fuel model codes and a table of fuel loading values for NFDRS fuel model categories (Cohen and Deeming, 1985). In addition to the default NFDRS fuel loadings, additional fuel loading was added to each category to adjust for fuel present as duff and tree crowns. Similarly, for prescribed fire events for which no fuel loading value was available, the prescribed fire fuel loading values were the same as those used for the wildfire inventory. "Adjusted" NFDRS fuel loading assignments for wildfire and prescribed burning differed by the percent consumption assumed for live fuels, duff, and crown components. Table 5 presents the adjusted NFDRS fuel loading assignments for wildfire and prescribed burning.

An emission factor suite was developed to apply to wildfire and prescribed fire activity data. The emission factor suite included one look-up table for wildfire and prescribed broadcast burns and one table for prescribed pile burns. The twelve pollutants included were total suspended particulate matter (TSP), particulate matter less than 10 microns in diameter (PM_{10}), particulate matter less than 2.5 microns in diameter ($PM_{2.5}$), elemental carbon (EC), organic carbon (OC), non-methane volatile organic compounds (VOC), methane (CH_4), ammonia (NH_3), oxides of nitrogen (NO_x), carbon monoxide (CO), sulfur dioxide (SO_2), and coarse particulate matter–defined as the difference between PM_{10} and $PM_{2.5}$ (PMC). The emission factor suite consists of two look-up tables. Two emission factor references were drawn upon: the U.S. Environmental Protection Agency's (U.S. EPA) AP-42 Section 13.1 and an emission inventory methods survey report (Battye, 2001) funded by the U.S. EPA Office of Air Quality Planning and Standards (OAQPS). The emission factor suite is a compilation of emission factors and emission factor relationships (multipliers) from both documents. Table 6 lists the emission factors used for the Phase II EI.

In addition to smoldering consumption incorporated into the NFDRS fuel loading table, distinct smoldering emissions were added to the emission inventory on the day after certain wildland fire days. The FEJF applied day-after smoldering to each day of a wildfire and prescribed broadcast burn with fuel loadings greater than 5.0 tons per acres (personal communication, David Sandberg, FEJF). Seventeen percent of the emissions on a wildfire day and 8.5 percent of the emissions on a prescribed broadcast burn day were added to the emission inventory at the same location on the following day. Prescribed pile burns did not have additional smoldering days added.

Table 5: Summary of Fuel Loading and Consumption by NFDRS Model

Dead and live fuel loadings were based on Cohen and Deeming (1985). Values in parentheses indicate total fuel loading for prescribed fire. An asterisk (*) after the NFDRS model description indicates the wildfire emissions were augmented for smoldering consumption.

NFDRS Abbr.	NFDRS Model Description	Total (Rx fire) (tons/acre)	Dead Fuels (tons/acre) 1-hour	10-hour	100-hour	1,000-hour	Live Fuels (tons/acre) Fine Wood	Herbaceous	Additional (tons/acre) Duff	Crown
A	Western grasses (annual)	0.50	0.20	0.00	0.00	0.00	0.00	0.30	0.00	0.00
B	California chaparral	19.5	3.50	4.00	0.50	0.00	11.50	0.00	0.00	0.00
C	Pine-grass savanna	4.7	0.40	1.00	0.00	0.00	0.50	0.80	4.00	0.00
D	Southern rough *	15.6 (10.6)	2.00	1.00	0.00	0.00	3.00	0.75	7.70	8.00
E	Hardwood litter (winter) *	3.8	1.50	0.50	0.25	0.00	0.50	0.50	1.10	0.00
F	Intermediate brush	15.0	2.50	2.00	1.50	0.00	9.00	0.00	0.00	0.00
G	Short needle (heavy dead) *	43.5 (25.6)	2.50	2.00	5.00	12.00	0.50	0.50	18.20	19.20
H	Short needle (normal dead) *	27.5 (15.0)	1.50	1.00	2.00	2.00	0.50	0.50	16.90	18.70
I	Heavy slash *	55.1 (49.1)	12.00	12.00	10.00	12.00	0.00	0.00	18.20	0.00
J	Intermediate slash *	34.0 (31.2)	7.00	7.00	6.00	5.50	0.00	0.00	16.90	0.00
K	Light slash *	14.4 (13.1)	2.50	2.50	2.00	2.50	0.00	0.00	9.70	0.00
L	Western grasses (perennial)	0.75	0.25	0.00	0.00	0.00	0.00	0.50	0.00	0.00
N	Saw grass *	5.0	1.50	1.50	0.00	0.00	2.00	0.00	0.00	0.00
O	High pocosin *	46.1 (45.1)	2.00	3.00	3.00	2.00	7.00	0.00	58.20	0.00
P	Southern pine plantation *	16.4 (10.2)	1.00	1.00	0.50	0.00	0.50	0.50	13.30	10.00
Q	Alaskan Black Spruce	57.6 (48.8)	2.00	2.50	2.00	1.00	4.00	0.50	57.90	26.80
R	Hardwood litter (summer) *	3.1	0.50	0.50	0.50	0.00	0.50	0.50	1.10	0.00
S	Tundra *	19.3 (19.1)	0.50	0.50	0.50	0.50	0.50	0.50	32.60	0.00
T	Sagebrush grass *	4.5	1.00	0.50	0.00	0.00	2.50	0.50	0.00	0.00
U	Western pines *	19.1 (10.3)	1.50	1.50	1.00	0.00	0.50	0.50	10.60	14.20

Table 6: Summary of Emission Factors

Summary of emission factors (EF) in pounds per ton for prescribed burning. In the case of piled fuels, when two sources are mentioned, the first source refers to the emission factor and the second to the empirical relationship used to derive that emission factor.

	Prescribed Fire Piled Fuels		Prescribed Fire Non-Piled	
Pollutant	EF	Source	EF	Source
TSP	12.0	AP42[1]	34.1	AP42
PM_{10}	8.0	AP42	28.1	OAQPS
$PM_{2.5}$	8.0	AP42	24.1	OAQPS
Elemental Carbon	0.6	AP42, OAQPS $PM_{2.5}$ * 0.072	1.5	OAQPS
Organic Carbon	4.3	AP42, OAQPS $PM_{2.5}$ * 0.54	11.6	OAQPS
VOC	6.3	AP42, OAQPS CO * 0.085	13.6	OAQPS
CH_4	7.7	OAQPS 2*(42.7-43.2*CE)	13.6	OAQPS
NH_3	0.5	AP42, OAQPS CO * 0.0073	1.3	OAQPS
NO_x	6.2	OAQPS	6.2	OAQPS
CO	74.3	AP42	289.0	OAQPS
SO_2	1.7	OAQPS	1.7	OAQPS
PM coarse	0.0	$PM_{10} - PM_{2.5}$	4.0	$PM_{10} - PM_{2.5}$

2.2.1 Pollutant Speciation

In the development of all of the fire emissions inventories (1996, 2002, 2018) prepared for the FEJF, Air Sciences and the WRAP's Regional Modeling Center (RMC) have relied upon mathematical relationships with other pollutants to derive estimates of varies species of pollutants, including, elemental carbon (EC), organic carbon (OC), ammonia (NH_3), and methane (CH_4). While the emission inventory system has included calculated estimates for several of these pollutant species, in general, the RMC has derived emission quantities for these pollutants as part of the pre-modeling data processing steps (i.e., the RMC has not used the values for EC, OC, NH_3, and CH_4 included in the emission inventory files provided by Air Sciences). This section simply documents the current mathematical relationships being utilized to represent emissions of EC, OC, NH_3, and CH_4 in the fire emissions inventory and modeling systems.

Table 7 includes the mathematical relationships currently utilized by the RMC to prepare estimates of several pollutant species.

[1] AP-42, Section 13.1, Table 13.1-3, Logging Slash Debris, No Mineral Soil, weighted average of flaming and smoldering.

Table 7: Pollutant Species' Mathematical Relationships Currently in use by RMC

Pollutant Species	Agricultural & Prescribed Multiplier	Pollutant Relationship	Wildfire Multiplier	Pollutant Relationship
EC	0.075	X $PM_{2.5}$	0.09	X $PM_{2.5}$
OC	0.6389	X $PM_{2.5}$	0.636	X $PM_{2.5}$
Nitrates (PN03) (particulate)	0.0063	X $PM_{2.5}$	0.0	X $PM_{2.5}$
Sulfates (PS04) (particulate)	0.0154	X $PM_{2.5}$	0.0	X $PM_{2.5}$
Fine particulate	0.2644	$PM_{2.5}$-EC-OC-PN03-PS04	0.274	$PM_{2.5}$-EC-OC-PN03-PS04
Aldehydes	0.205	X VOC	0.205	X VOC
Ethanes	0.1911	X VOC	0.1911	X VOC
Non-reactive hydrocarbons	0.2247	X VOC	0.2247	X VOC
Olefins	0.0310	X VOC	0.0310	X VOC
Paraffins	0.5511	X VOC	0.5511	X VOC

Air Sciences' emission inventory systems have not included estimates for all of the pollutant species identified in Table 7 (above). Table 8 includes the mathematical relationships currently utilized in Air Sciences' emission inventory system to prepare estimates of several pollutant species. For species for which the emission factors were taken directly from the literature, Table 8 shows the calculated relationship between the pollutant species and the parent pollutant. For agricultural burning, emission factors as provided by Bryan Jenkins, Ph.D., UC Davis, are crop-specific and the derivation of each pollutant's emission factor is not provided. Therefore, Table 8 shows the range, average (avg), and median (med) of the mathematical relationship between the pollutant species and the parent pollutant.

Table 8: Pollutant Species' Mathematical Relationships Currently in use in Air Sciences Emission Inventory System

	Wildland Fire (wildfire and Rx broadcast burns)		Prescribed Fire - Piled Fuels		Agricultural Burning	
Pollutant	EF	Source/ Relationship	EF	Source/ Relationship	EF	Source/ Relationship
Elemental Carbon	1.5	OAQPS/ 0.6224 x $PM_{2.5}$	0.6	AP42, OAQPS $PM_{2.5}$ * 0.072	Varies by crop.	0.15 to 0.31 x $PM_{2.5}$ avg = 0.25 med = 0.26
Organic Carbon	11.6	OAQPS/ 0.4813 x $PM_{2.5}$	4.3	AP42, OAQPS $PM_{2.5}$ * 0.54	Varies by crop.	0.21 to 0.5 x $PM_{2.5}$ avg = .44 med = .45
VOC	13.6	OAQPS/ 0.047 x CO	6.3	AP42, OAQPS CO * 0.085	Varies by crop.	0.04 to 0.18 x CO avg = 0.10 med = 0.09
CH_4	13.6	OAQPS	7.7	OAQPS 2*(42.7-43.2*CE) CE=0.9	Varies by crop.	0.82 to 19.76 avg = 7.78 med = 8.60
NH_3	1.3	OAQPS/ .0045 x CO	0.5	AP42, OAQPS CO * 0.0073	Varies by crop.	0.02 x CO
PM coarse	4.0	PM_{10} – $PM_{2.5}$	0	PM_{10} – $PM_{2.5}$	Varies by crop.	PM_{10} – $PM_{2.5}$
Reference:						
PM_{10}	28.1	OAQPS	8.0	AP42	Varies.	UC Davis
$PM_{2.5}$	24.1	OAQPS	8	AP42	Varies.	UC Davis
CO	289	OAQPS	74.3	AP42	Varies.	UC Davis

2.3 Emission Calculations

For wildfire and prescribed burning, daily emissions were calculated as fuel consumed (tons of fuel) multiplied by each emission factor (pounds of pollutant per ton of fuel). Total fuel consumed was either extracted directly from the activity data (more often the case with prescribed fire) or was calculated as the size of the fire (acres burned) multiplied by the "adjusted" NFDRS fuel loading value (tons of fuel per acre burned). For wildfires and prescribed broadcast burns of fuel model types with a fuel loading greater than 5 tons per acre, additional smoldering emissions were assigned to the same location on the following calendar day.

2.3.1 Daily Fire Growth Allocation

The wildfire and prescribed burn emission inventories were required to be resolved to the day, but wildfires and prescribed burns were reported both as individual fire days and as single records spanning a number of days. Therefore, the acres burned, total fuel loading consumed, and emissions per pollutant of multi-day records were allocated to individual days to indicate their "fire growth." In the emission inventory database, new records were appended to add new daily fire events where before there was only a single multi-day record. The final date for all records was coded in "mm/dd/yy" format. The original multi-day record was overwritten with the first day's allocation.

Records that only indicated one day's reporting of activity (i.e., the end date was the same as the start date) were skipped over by this daily allocation step. A multi-day event was allocated to individual fire days only if its size was greater than 100 acres. Fires less than or equal to 100 acres were assigned in their entirety to the activity record's start date. The growth rate for wildfires and prescribed fires was then allocated differently:

Wildfire

Wildfire and WFU events greater than 100 acres were allocated to the first two-thirds of the duration implied in the source data. The duration of fire growth in days for wildfire was calculated as:

Wildfire Duration ($Days_n$) = Ceiling [2/3 (startdate – enddate + 1)] **Equation 1**

Beginning on the start date, values were allocated to the subsequent calendar days across this shortened duration. The FEPS "spreading oval" algorithm was used to emulate a geometric fire growth (FEPS version 1.0 Jan-04 Eqn. 20). The fire growth of each day as a percent of the multi-day total was calculated as:

Percent $Day_i = (Day_i^2 / Days_n^2)) - (Day_{i-1}^2 / Days_n^2)$ **Equation 2**

Where: i = sequence number of day from the event's start date, and
n is the total number of days in the shortened wildfire duration from Equation 1.

The daily allocation percent was applied to the multi-day values to arrive at daily fire growth in acres burned, tons consumed, and tons emitted per pollutant.[2]

Prescribed Fire

For multi-day prescribed fires greater than 100 acres, size, loading, and emissions were allocated evenly across every day from reported start date to end date, inclusive.

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[2] The ETT recognizes that the spreading oval technique may not accurately represent the daily growth rate of large multi-day events in certain fuel types in Alaska. The FEJF may wish to revise the daily fire growth allocation for Alaska fire events in future emission inventories.

2.4 Plume Profile

A plume profile tailored for wildland fire was assigned to each daily fire event. Normally, plume rise is predicted using hourly pyrotechnical and meteorological information. However, given the unique physical characteristics of wildland fire events and previous experience with dispersion models that indicated poor performance with regard to dispersing smoke plumes, the FEJF utilized expert opinion to assign plume characteristics to each fire event.

2.4.1 Virtual Acres

Fires were classified into size classes based on "virtual acreage." The virtual acreage was calculated by multiplying the actual fire size by the square root of the normalized pre-burn fuel loading (Equation 3). This was done in order to relate fuel loading to the characteristic "stack" diameter of the plume. Total fuel loading was normalized to 13.8 tons per acre for wildfire and 5.0 tons per acre for prescribed fire. The normalizer for wildfire was equal to the total surface loading plus a portion of the crown biomass of NFDRS fuel model U (western pines). The prescribed fire normalizer is equal to the surface loading only of NFDRS fuel model U.

$$\text{Acreage}_{\text{virtual}} = \text{Acreage}_{\text{actual}} \cdot \sqrt{\text{Fuel Loading / Normalizer}} \qquad \textbf{Equation 3}$$

The plume profile for days added to model smoldering for the day after an original activity day was the same as for the original fire event. In the emission inventory, the smoldering events retained the virtual acreage of the fire event they were created from, and thus the plume calculations were identical.

2.4.2 Diurnal Consumption

A diurnal fuel consumption table was created to allocate daily wildland fire emissions by hour (Table 9). The table, consisting of a percent of fuel consumed for each hour of the day, summing to 100, was submitted to the Air Quality Modeling Forum (and the WRAP's Regional Modeling Center [RMC]). The diurnal fuel consumption table was implemented by the RMC within the SMOKE emissions processor to allocate daily emission estimates to hourly emissions.

Table 9: Standard Diurnal Consumption Template Used to Distribute Fire-Total Heat Production and Emissions

Hour	1	2	3	4	5	6	7	8	9	10	11	12
% Per Hour	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	2.00	4.00	7.00

Hour	13	14	15	16	17	18	19	20	21	22	23	24
% Per Hour	10.00	13.00	16.00	17.00	12.00	7.00	4.00	0.57	0.57	0.57	0.57	0.57

2.4.3 Fire Size Classes and Plume Profile Calculations

Plume values include the top and bottom of the plume (Ptop and Pbot, respectively; both expressed in meters above ground elevation) and the percent of emissions entrained within the surface layer of the atmosphere (Lay1F), defined by the ETT of the FEJF as the first 38 meters above the ground.[3] These three plume parameters are established and assigned for each of the 24 hours of each daily fire event. All of the plume values were assigned based on the limited information available for each fire event, including fire size (fire area grown per day) and either a reported fuel loading or the NFDRS fuel model.

Five plume classes were defined with increasing potential plume heights to reflect the range of "heat release" possible in wildland fires (Table 10). Plume bottom heights and percent of the plume fumigated to the first layer of the atmosphere were also developed for the five plume classes. Using expert opinion and anecdotal evidence, a table of hourly buoyant efficiency values was derived (Table 11).

Table 10: Fire-Related Parameters as Function of Fire Size Classes

Class	1	2	3	4	5
Size (virtual acres)	0 – 10	>= 10 – 100	>= 100 – 1,000	>= 1,000 – 5,000	>= 5,000
BE_{size}	0.40	0.60	0.75	0.85	0.90
Ptop max (m)	160	2,400	6,400	7,200	8,000
Pbot max (m)	0	900	2,200	3,000	3,000

Table 11: Buoyant Efficiency as Function of Hour of Day

Hour	1	2	3	4	5	6	7	8	9	10	11	12
BE_{hour}	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.06	0.10	0.2	0.4

Hour	13	14	15	16	17	18	19	20	21	22	23	24
BE_{hour}	0.7	0.8	0.9	0.95	0.99	0.8	0.7	0.4	0.06	0.03	0.03	0.03

Equations were used to calculate Ptop and Pbot as a function of time of day and size of the fire (expressed in terms of virtual acres). Note that the calculations used an hourly value for buoyant efficiency (Table 11) and heat release value based on fire size, also referred to as normalized fire growth.

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[3] The height of the first (lowest) vertical layer is 38 m in the WRAP's Regional Modeling Center's model setup. The calculation methodology for the Lay1F values have been reviewed (by Air Sciences and the USDA Pacific Wildland Fire Sciences Lab) and assessed to be reasonable with no additional scaling. The maximum bottom of plume values was revised downward for the three largest fire size classes (also based on discussions with the USDA Pacific Wildland Fire Sciences Lab).

The hourly top of the plume was calculated as follows:

$$Ptop_{hour} = (BE_{hour})^2 * (BE_{size})^2 * Ptop_{max}$$ **Equation 4**

Where: BE is the buoyant efficiency looked up from the hourly or size class tables. The hourly bottom of plume was similarly calculated as:

$$Pbot_{hour} = (BE_{hour})^2 * (BE_{size})^2 * Pbot_{max}$$ **Equation 5**

Lastly, an equation was used to calculate Lay1F, the proportion of emissions fumigated into the first atmospheric layer. Lay1F was calculated as the arithmetic inverse of the hour-specific buoyant efficiency multiplied by the size-specific buoyant efficiency.

$$Lay1F_{hour} = 1 - (BE_{hour} * BE_{size})$$ **Equation 6**

Using Equations 3 through 6, the bottom and top of the atmospheric plume as well as the proportion of the plume fumigated into the first atmospheric surface layer were all scaled to fire size, fuel loading (incorporated in virtual acres calculation), and hour of the day. Figures 1 through 4 illustrate the relationships described above.

Figures 1 through 9 illustrate the hourly plume characteristics (Ptop, Pbot, and Lay1F) assigned to each of the five fire size classes into which daily fire events in the Phase II EI have been assigned (Class 1 - less than 10 acres; Class 2 – 10 to 100 acres; Class 3 – 100 to 1,000 acres; Class 4 – 1,000 to 5,000 acres; Class 5 – greater than 5,000 acres). Also shown on Figures 5 through 9 is the height (38 m) of the first vertical atmospheric layer (as designated by the WRAP's RMC).

Figure 1: Buoyant Efficiency

The relationship between buoyant efficiency and time of day.

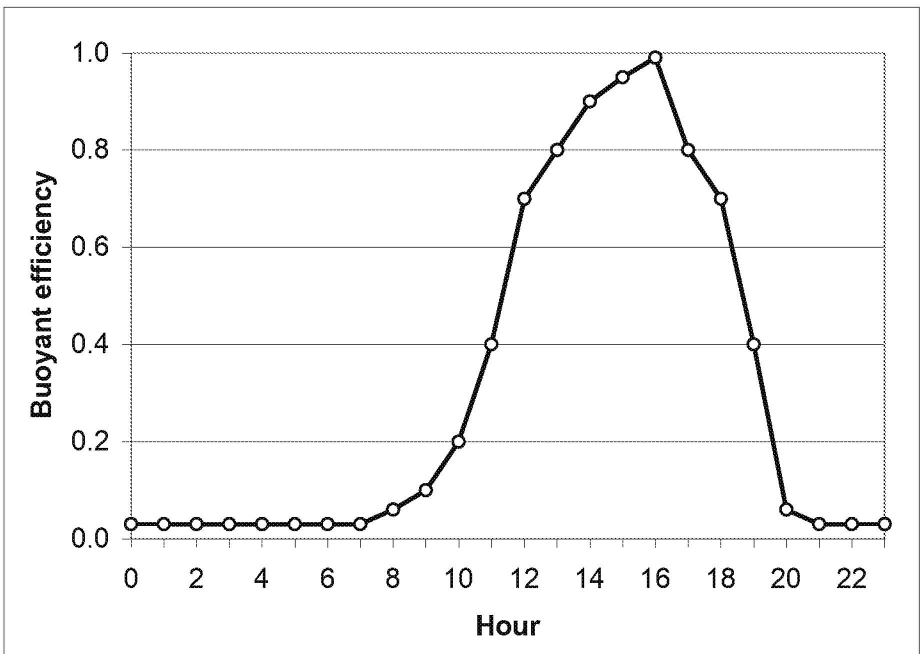
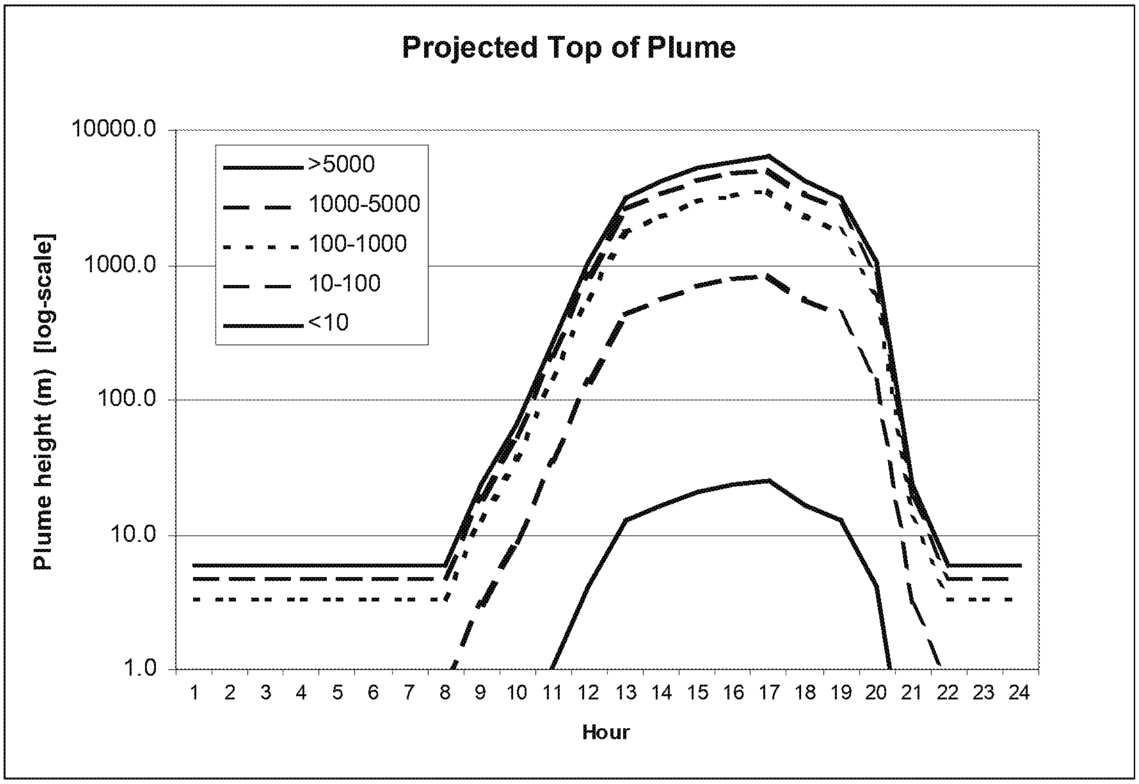


Figure 2: Projected Top of Plume

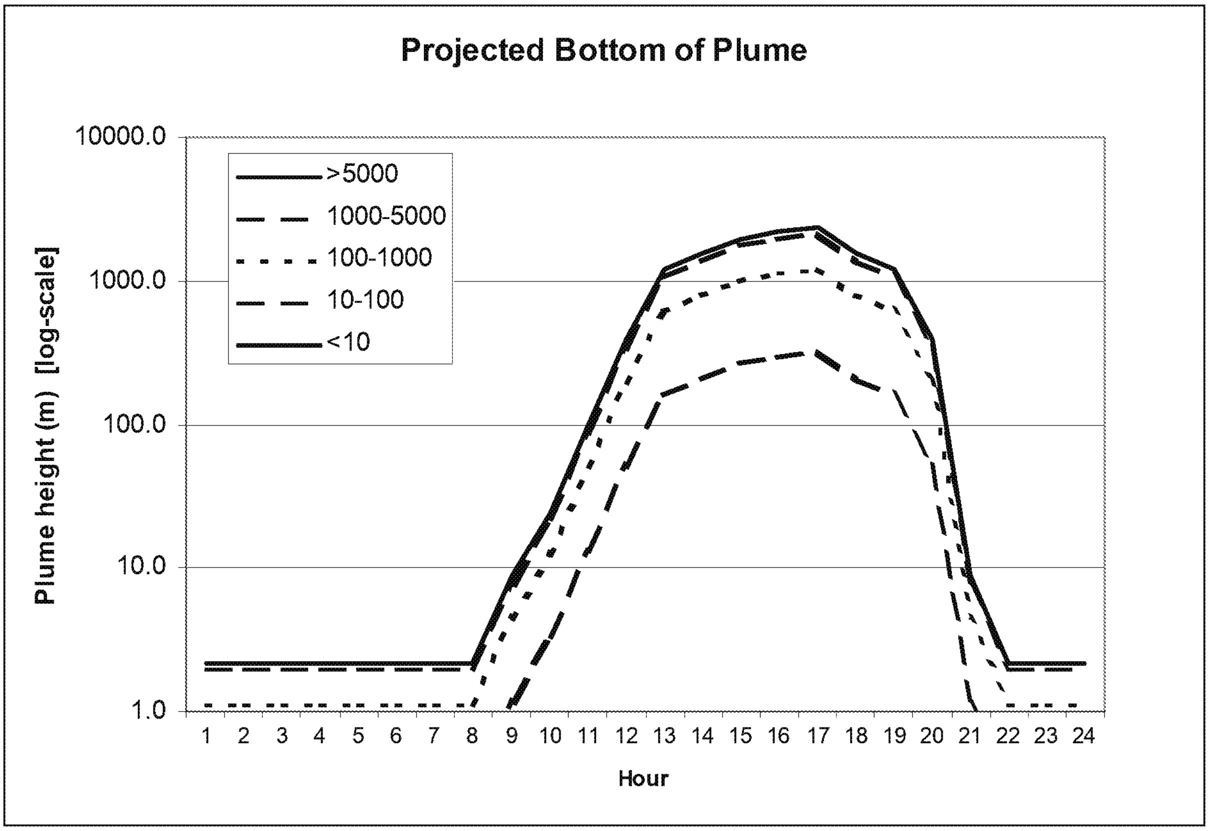
The projected top of the atmospheric plume (meters) as a function of time of day and fire size. Fire sizes represent the upper cutoff of the fire size categories. The lowest line represents the 10-acre cutoff. Note the logarithmic scale on the Y-axis.



ED_014139_00001061-00029

Figure 3: Projected Bottom of Plume

The projected bottom of the atmospheric plume (meters) as a function of time of day and fire size. Fire sizes represent the upper cutoff of the fire size categories. The line representing the 10-acre cutoff is constant at a value of zero.



ED_014139_00001061-00030

Figure 4: Proportion of Plume in Surface Layer

The proportion of the plume fumigation to the atmospheric surface layer (<38 m) as a function of time of day and fire size. Fire sizes represent the upper cutoff of the fire size categories. The highest line represents the 10-acre cutoff.

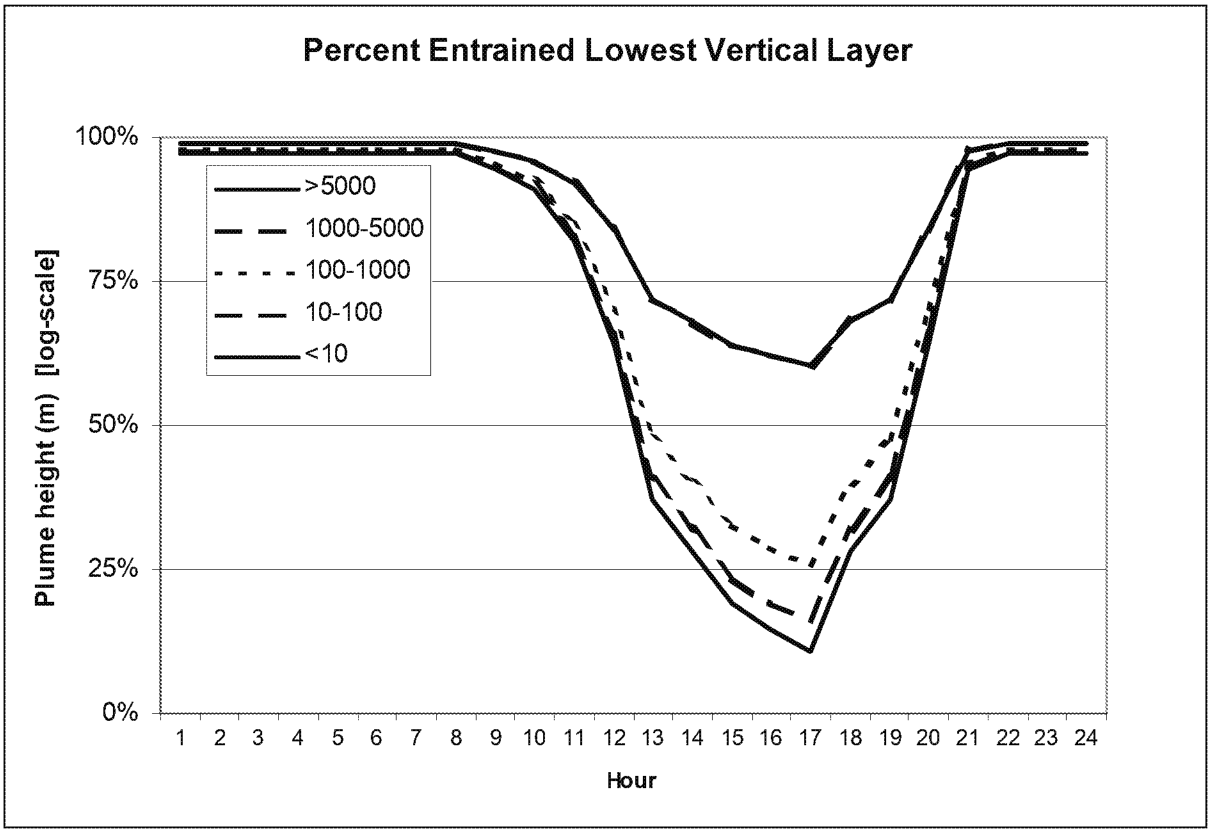


Figure 5: Fire Size Class 1 Plume Characteristics

This figure shows plume characteristics (Ptop, Bbot, and Lay1F) for Class 1 fires for each hour. Plume height in meters is shown on the left Y-axis (in log-scale), and Lay1F in percent entrained into the lowest vertical layer is shown on the right Y-axis. For reference, the height of the lowest vertical layer (38 m) is shown in red.

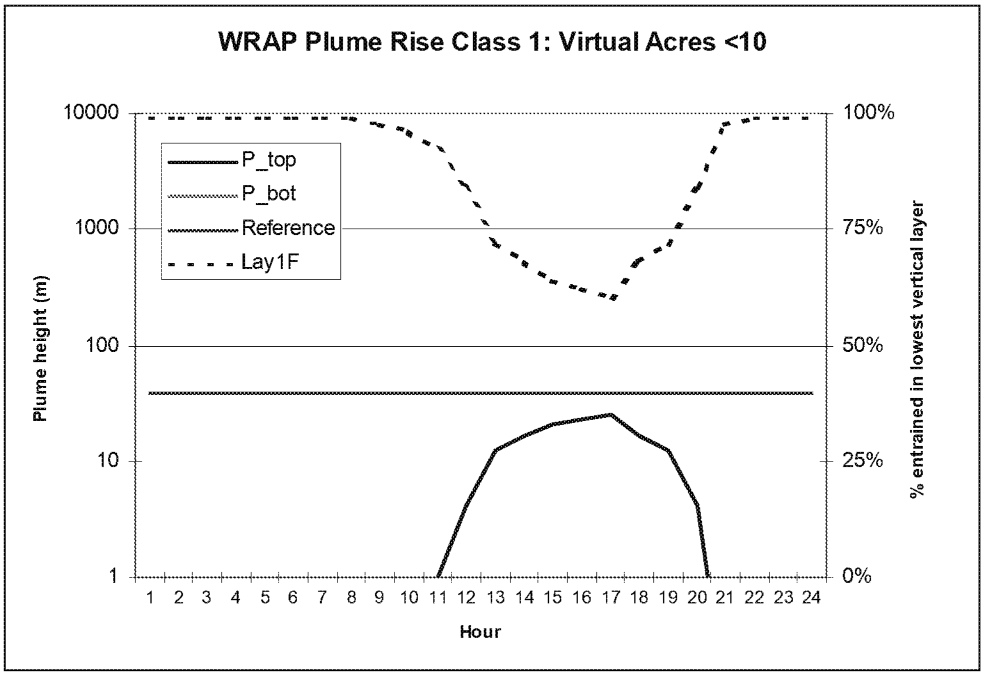


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Figure 6: Fire Size Class 2 Plume Characteristics

This figure shows plume characteristics (Ptop, Bbot, and Lay1F) for Class 2 fires for each hour. Plume height in meters is shown on the left Y-axis (in log-scale), and Lay1F in percent entrained into the lowest vertical layer is shown on the right Y-axis. For reference, the height of the lowest vertical layer (38 m) is shown in red.

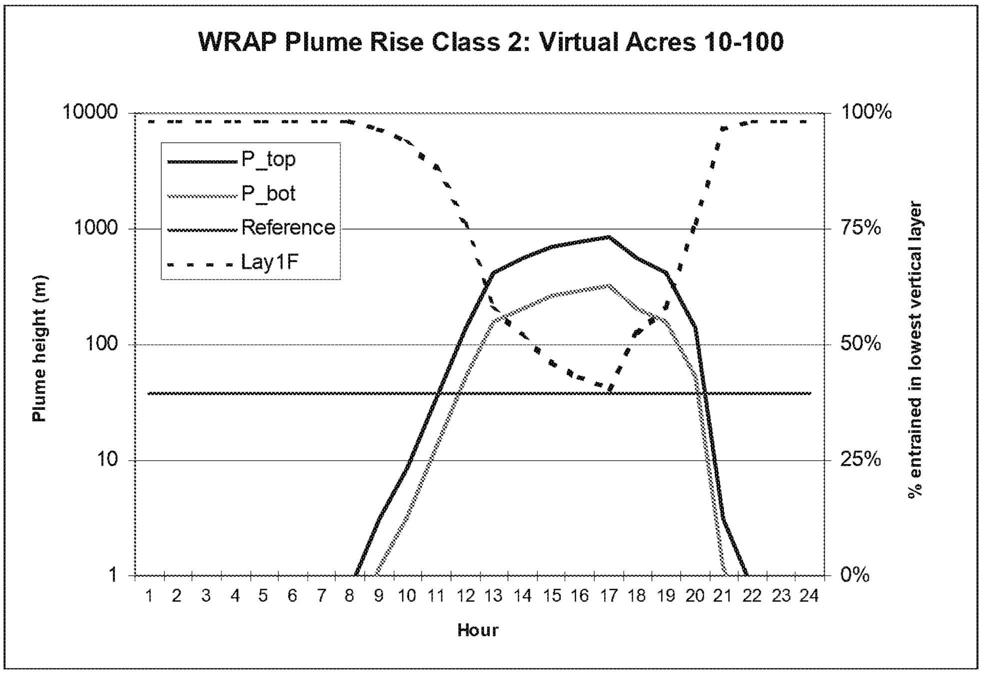

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Figure 7: Fire Size Class 3 Plume Characteristics

This figure shows plume characteristics (Ptop, Bbot, and Lay1F) for Class 3 fires for each hour. Plume height in meters is shown on the left Y-axis (in log-scale), and Lay1F in percent entrained into the lowest vertical layer is shown on the right Y-axis. For reference, the height of the lowest vertical layer (38 m) is shown in red.

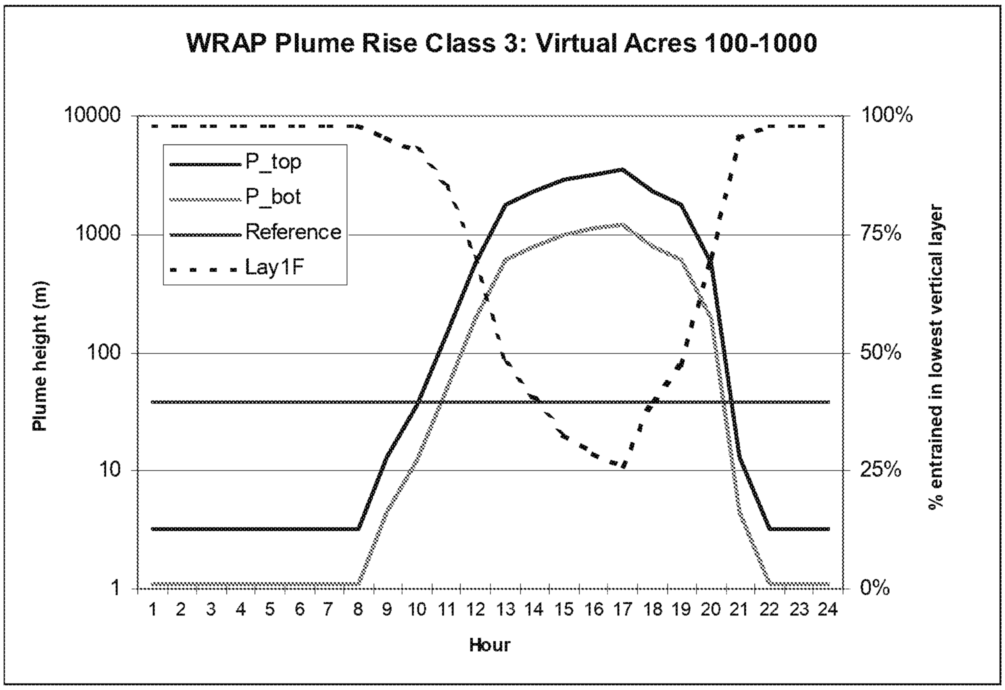

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Figure 8: Fire Size Class 4 Plume Characteristics

This figure shows plume characteristics (Ptop, Bbot, and Lay1F) for Class 4 fires for each hour. Plume height in meters is shown on the left Y-axis (in log-scale), and Lay1F in percent entrained into the lowest vertical layer is shown on the right Y-axis. For reference, the height of the lowest vertical layer (38 m) is shown in red.

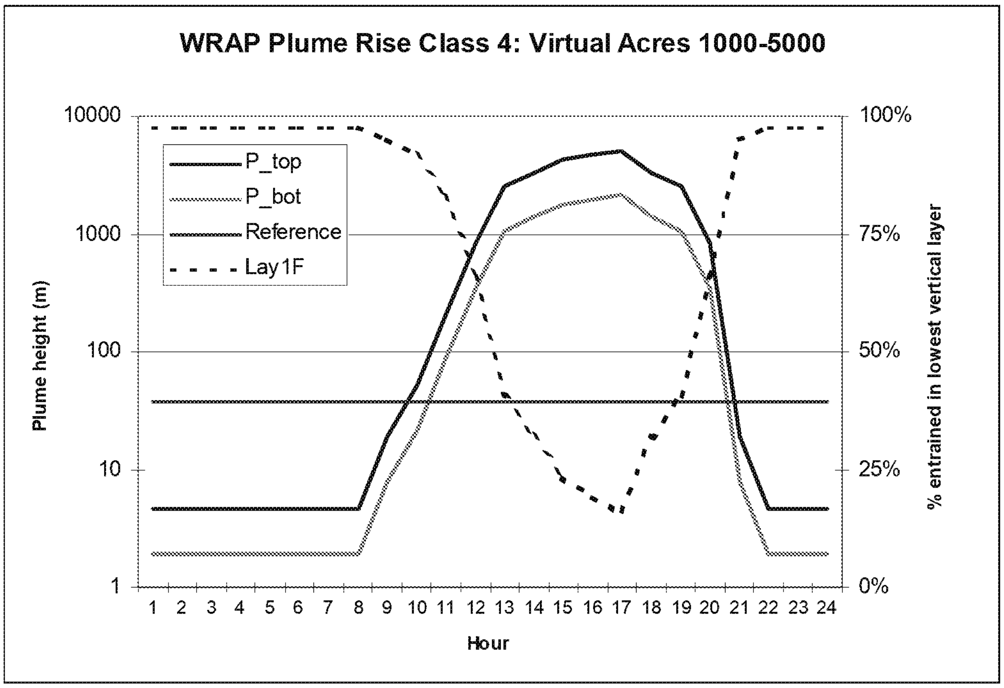

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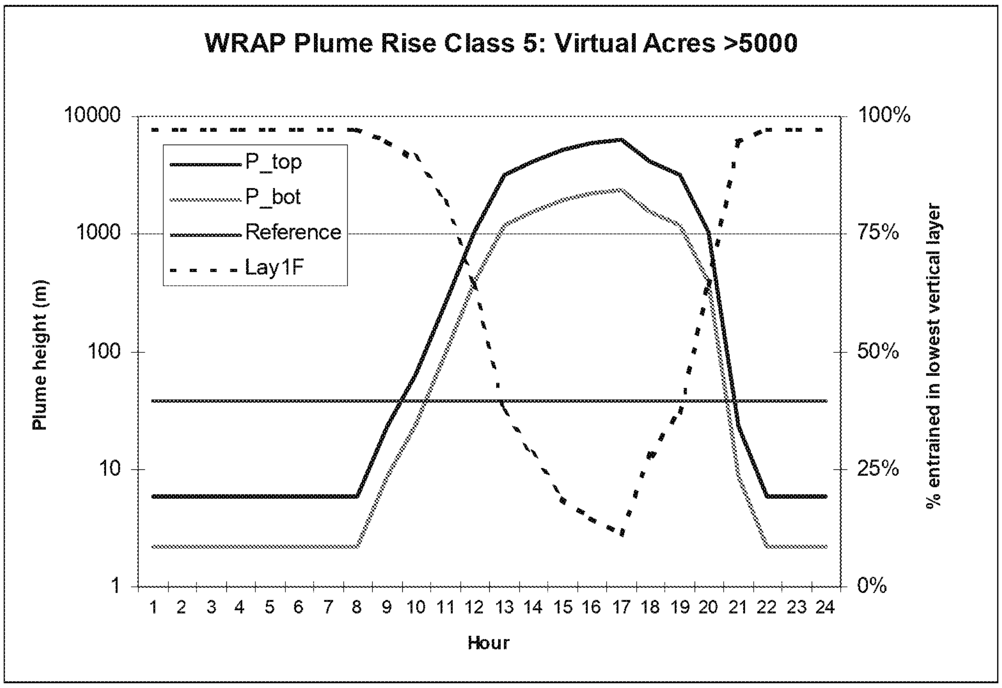
Figure 9: Fire Size Class 5 Plume Characteristics

This figure shows plume characteristics (Ptop, Bbot, and Lay1F) for Class 5 fires for each hour. Plume height in meters is shown on the left Y-axis (in log-scale), and Lay1F in percent entrained into the lowest vertical layer is shown on the right Y-axis. For reference, the height of the lowest vertical layer (38 m) is shown in red.



2.5 Approach for Technical Refinements of Large Fires and Fire Complexes for WRAP Phase I Fire Emission Inventory

This section summarizes the proposed technical approaches to refine the wildfire activity data represented in the Western Regional Air Partnership (WRAP) Phase I EI. The technical approaches for the three following tasks are discussed in this section.

- Complex fire identification.
- Identification of blackened versus perimeter acres.
- Refinements of spatial, temporal, and fuel loading data for large fires.

In order to address these tasks, the largest 28 wildfires in the Phase I EI (all near or above 50,000 acres) were examined for availability of more refined spatial data. This information was obtained through Internet searches combined with follow-up phone calls with the appropriate Federal Land Manager (FLM). The type of fire-event-specific information included Burned Area Emergency Response reports (BAER reports), Environmental Impact Statements, GIS-files provided by the national forests or obtained through the internet, as well as other web-based fire event information. Availability of these resources varied from fire to fire. Table 12 presents the list of large fires for which the availability of fire-specific digital information was researched. The list of fire complexes researched includes those in Table 12, as well as several smaller fire complexes.

Table 12: Summary of Available Data for Large Wildland Fires in Phase I EI
"---" indicates no data available or located.

Fire Name	State	Perimeter Acres	Fuels Information	Fire Severity Information	GIS-based Fire Perimeter
Biscuit	OR	499,570	Tabular[1]/GIS	Tabular	GIS[4]
Rodeo/Chediski	AZ	468,638	Tabular[1]/GIS	Tabular/GIS[3]	GIS[3]
Geskamina Lake	AK	257,258	GIS	---	Fire history GIS
Reindeer	AK	227,800	GIS	---	Fire history GIS
Minunchima Group	AK	196,584	GIS	---	Fire history GIS
Yetna River	AK	152,962	GIS	---	Fire history GIS
McNalley	CA	150,696	Tabular[1]/GIS	Tabular/GIS[3]	GIS[3]
Hayman	CO	137,760	Tabular[2]/GIS	Tabular/GIS[3]	GIS[3]
Sischu	AK	128,983	GIS	---	Fire history GIS
Tool Box	OR	120,085	Tabular[1]/GIS	GIS[4]	GIS[4]
Moose Lake	AK	117,648	GIS	---	Fire history&GIS[3]
MP 78	AK	115,328	GIS	---	Fire history GIS
Rattle	UT	94,519	GIS	Tabular/GIS[4]	GIS[4]
Ponil Complex	NM	92,194	GIS	GIS[4]	GIS[4]
Vinasale	AK	92,000	GIS	---	Fire history GIS
Long Creek	AK	74,931	GIS	---	Fire history GIS
Galatea Creek	AK	74,511	GIS	---	Fire history GIS
Kraft Springs	MT	69,900	Tabular[1]	Tabular	---
Windy	AK	69,523	GIS	---	Fire history GIS
Tiller Complex	OR	68,775	GIS	GIS[4]	GIS[4]
Missionary Ridge	CO	66,534	GIS	Tabular/GIS[3]	GIS[3]
Sanford	UT	64,972	Tabular[1]/GIS	Tabular/GIS[4]	GIS[4]
Spurs	AK	64,834	GIS	---	Fire history GIS
Bear Creek	AK	63,634	GIS	---	Fire history GIS
Pines	CA	61,705	---	---	---
Khotol Riv	AK	50,811	GIS	---	Fire history GIS
Boulder	OR	48,080	---	---	---
Kraft Complex	ND	48,000	---	---	---
Acres Researched		3,678,235 (58 % of Phase I WF EI)			
GIS Acres (potential)		3,512,255 (55 % of Phase I WF EI)			

Notes: 1 Tabular fuel model distribution derived from vegetation descriptions (hardcopy).
2 Tabular fuel model provided by source (hardcopy).
Digital GIS fire perimeter data was either downloaded from the internet (GIS 3) or obtained from the U.S. Forest Service (GIS 4).

2.5.1 Complex Fire Identification

2.5.1.1 Analysis and Results

The goal of this analysis was to identify potential duplicate fire entries that might be present in the database. A fire event could occur more than once in the emission inventory database if, for example, the fire name was changed over the course of time. This can occur when multiple fires are merged into a single fire complex. In this situation, the initial fire names are generally dropped, and all fires get assigned a common name. The Alaska fires could not be checked for the potential of duplicates since information on individual fires that might make up the larger complexes was not available (personal communication, Sue Christensen, Alaska Fire Service). Of the fire complexes in the WRAP states in the lower 48 the following fires were examined:

1. Wildfires (including WFU) above approximately 50,000 acres, regardless of fire name.
2. Wildfires (including WFU) between 6,000 and 50,000 acres with names ending in "Complex."

Although all fires with names ending in "Complex" were identified, only those above 6,000 acres (cumulative acres) were researched in the (online) National Fire Incident Situation Reports for 2002. The portion of fire complexes not included in the analysis contained 23 fire complexes sized from 100 to ~4,000 acres, and totaling ~26,000 acres. The fire complexes were examined for (1) the individual fires that made up the complex and (2) the potential duplicate presence of these individual fires in the Phase I EI based on fire name and fire event date(s).

Table 13 summarizes the results for the fire complexes included in this research. For the total of 24 large fires and fire complexes that were researched, 18 were identified as actual fire complexes. Out of these 18 fire complexes, 13 complexes had potential duplicate entries in the Phase I EI, based on 26 potential duplicate fires. A total of approximately 260,000 acres that might have been double-counted in the Phase I EI was identified. In the second step of this quality control procedure, these potential duplicates were compared by fire location. Specifically, the distance from the fire complex coordinates to the coordinates of its comprising fires was calculated. The distances varied from zero (identical coordinates) to approximately 57 miles. Most of the calculated distances were short enough to fall within a reasonable fire perimeter based on the size of the fire.

Table 13: Summary of Complex Fire Check Based on Duplicate Names Only

"---" indicates no duplicates found by checking fire names; "NA" indicates not applicable.

Fire Name	State	Perimeter Acres	Fires Included in Phase I EI Event	Potential Duplicate Events Identified (acres)	Distance (mi)
			Biscuit fire	Sour Biscuit (41,897 acres)	25
			Florence fire	---	---
Biscuit	OR	499,570	Sourdough fire	---	---
			Chediski fire	---	---
Rodeo/Chediski	AZ	468,638	Rodeo fire	---	---
McNalley	CA	150,696	One fire name only	NA	---
Hayman	CO	137,760	One fire name only	NA	---
			Toolbox fire	---	---
			Silver fire	Silver (24,565)	8
Tool Box	OR	120,085	Winter fire	Winter (69,673; 2 duplicate sets)	21
			Black Canyon fire	Black Canyon (5,970)	0
Rattle	UT	94,519	Diamond Creek fire	Diamond Creek (1,300)	14
			Middle Ponil Fire	---	---
			Medcalf Fire	---	---
			Office Fire	---	---
Ponil Complex	NM	92,194	Turkey	Turkey (1,295)	13
Kraft Springs	MT	69,900	One fire name only	NA	---
			Tallow	Tallow (1,132)	7
			Acker	Acker (4,114)	3
			Boulder fire	Boulder (48,080)	3
			Buckeye	Buckeye (2,212)	5
			Big Bend	Big Bend (10,063)	6
			Ruby Red	---	---
			Buster Springs	---	---
			Digger	---	---
			Anderson	Anderson (457)	12
Tiller Complex	OR	68,775	Wilderness	---	---
Missionary Ridge	CO	66,534	One fire name only	NA	---
			Sanford Rx burn	---	---
Sanford	UT	64,972	Adams Rx burn	---	---
			Kraft	---	---
			Bale II	Bale II (1,076)	28
			Twin II	Twin II (450)	23
Kraft	ND	48,000	Kenel Again	---	---

Table 13: Summary of Complex Fire Check Based on Duplicate Names Only - continued

"---" indicates no duplicates found by checking fire names; "NA" indicates not applicable.

Fire Name	State	Perimeter Acres	Fires Included in Phase I EI Event	Potential Duplicate Events Identified (acres)	Distance (mi)
Monument-Malheur	OR	44,062	Roberts	---	---
			Easy	---	---
			Monument	---	---
Daley	WY	42,000	Daley Draw	---	---
			Hairy	Hairy (13,000)	1
Mahogany	OR	41,328	Atkins	Atkins (800)	12
			Mahogany Mountain	---	---

Trinidad	CO	33,000	Spring	---	---
			James John	---	---
Mt. Zirkel	CO	31,016	Burn Ridge	Burn Ridge (8,260)	0
			Hinman	Hinman (10,176)	7
Quartz Mt.	WA	12,144	Quartz Mountain	---	---
			Middle Mountain	Middle Mountain (7,858)	5
			Lake	---	---
			Beauty Peak Action #344	---	---
Lincoln County	CO	10,000	One fire name only	NA	NA
Canyons	UT	9,800	Hang Dog	---	---
			Hammond	---	---
Inyo	CA	6,550	Fuller	Fuller (6,400)	7
			Piper	Piper (150)	1
Frank Church	ID	6,341	Parker Mountain	Parker Mountain (301)	32
			Little Horse	---	---
			Little Soldier	Little Soldier (303)	57
			Bobtail	---	---
			Waterfall	Waterfall (36)	23
			Big Hill	---	---
Grizzly	OR	6,050	Grizzly	---	---
			Bare	Bare (35)	16
			Logan	---	---
El Paso County	CO	6,000	One fire name only	NA	NA
Acres Researched		2,129,934 (33% of Phase I WF EI)		259,603 (4% of Phase I WF EI)	

2.5.1.2 Results of Complex Fire Identification Analyses

- The potential duplicate fires were identified by (1) the same name as reported in the individual daily fire reports, (2) overlapping fire date, and, (3) similarity of geographical coordinates. Based on these similarities, all potential duplicate fires recorded in Table 13 were removed from the emission inventory. The data for these deleted records will be retained in a companion database.

2.5.2 Blackened Versus Perimeter Fire Acres

Based on the fire event-specific information obtained for the largest 28 wildfires in the Phase I EI, the percentage of the acreage within the fire perimeter that did not burn was extracted. A range of 4 to 54 percent of the acreage within the analyzed fire perimeters reportedly did not burn. Table 14 presents a summary of the results of the blackened area analysis.[4] A grand total of approximately 343,000 acres of wildfire activity were removed from the fire activity database (a reduction of 5 percent of the total wildfire acres burned in the Phase I EI). Blackened acres could not be calculated for the Alaska fires since burn severity data were not collected for these fire events (personal communication, Sue Christensen, Alaska Fire Service). In this case it was assumed that the blackened acres and the perimeter acreage were the same for the large Alaska fire events. This is a reasonable assumption, given that most of these fires occurred in the interior of Alaska, and generally were characterized as intense, stand replacing wildfires (personal communication, Sue Christensen, Alaska Fire Service).

As a follow-up to these blackened acres refinements, selected fires were analyzed to detect any trends in this data based on NFDRS fuel model. The goal of this analysis was to see if there was a relationship between the proportion of blackened acres and the NFDRS fuel model, which potentially could be used to estimate blackened acres for smaller fires in the Phase II EI, as well as for fires in future emission inventories. The data were summarized as the proportions of unburned acreage and blackened acres (low, moderate, and high fire severity combined) for six fires and fire complexes (Table 13). Fire severity data were available in the form of GIS layers (Ponil and Sanford) or (hardcopy) reported fire intensities by vegetation type or NFDRS (Biscuit, Kraft, McNally, Rodeo-Chediski). The results indicated that the blackened acres within a perimeter varied considerably between NFDRS fuel models (average blackened acres 25 to almost 100 percent of perimeter). Moreover, blackened acres within a perimeter varied considerably within NFDRS fuel models as well, as indicated by the fairly high standard deviation in some cases (Table 13).

[4] Air Sciences Inc. has discovered that blackened versus fire perimeter information may also be available for two additional wildfire events (the Tool Box [120,000 acres] and Tiller Complex [68,775 acres] fires). To date, this information (in GIS format) has not been analyzed, and any potential reduction in acres burned for these events has not been accounted for in the Phase II EI.

Table 14: Summary of Blackened Versus Perimeter Fire Acres for Large Wildfire Events
"SD" stands for standard deviation.

Fire Name	State	Perimeter Acres	Unburned Acres (%)	Blacked Acres	Reduction of Acres in EI
Biscuit	OR	499,570	23	384,669	114,901
Rodeo/Chediski	AZ	468,638	15	398,342	70,296
McNalley	CA	150,696	10	135,626	15,070
Hayman	CO	137,760	20	110,208	27,552
Rattle	UT	94,519	54	43,479	51,040
Ponil Complex	NM	92,194	16	77,443	14,751
Kraft Springs	MT	69,900	4	67,104	2,796
Missionary Ridge	CO	66,534	20	53,227	13,307
Sanford	UT	64,972	50	32,486	32,486
Overall Acres		**1,644,783**	24 ± 17 (SD)	**1,302,584**	**342,199**
% WF EI Acres		**26%**		**21%**	**5%**

A further refinement could consist of expressing the blacked acreage as their proportion distributed over three fire severity categories typically used in BAER reporting, low, moderate and high fire severity, respectively. For the six fires in this analysis the distribution of blackened acres over the three fire severity classes did vary considerably, both between NFDRS fuel models as well as within each NFDRS fuel model (Table 14). The latter is demonstrated by the high standard deviation in comparison with the mean percentages. This variation makes it difficult to generalize this categorization to other fires in the WRAP region.

Table 15: Summary of Unburned Versus Blackened Acres for Six Fires
"SD" indicates one standard deviation, and "---" means not calculated due to a sample size of one. "*" indicates a statistically significant difference between unburned and blackened acres (Kruskal-Wallis test; P<0.05).

NFDRS	Sample Size	Percent of Perimeter Unburned	Percent of Perimeter Blackened	SD
A	3	7	93	6
B	2	3	97	4
C*	5	23	77	20
F*	4	26	74	27
G	1	75	25	---
H	5	29	71	26
L	1	0	100	---
R	3	34	66	53
T	1	60	40	---
U*	4	4	96	3
Overall*	**29**	**23**	**77**	**27**

2.5.2.1 Results of Blackened Versus Perimeter Refinement Analyses

Accounting for the unburned sections within fire perimeters decreased fire acreage between 4 to over 50 percent for a subset of large fires. Adjustments for blackened acres for these large fires were implemented in the Phase II EI.

The proportion of blackened acres relative to the perimeter acres did vary considerably, was based on a very small number of fires, and did not represent all NFDRS fuel models present in the Phase I EI. Therefore, these proportions were not applied to adjust acreage of other fires in the Phase II EI.

The variation in fire severity by NFDRS fuel model was too high to derive a general approach to adjust other fires in the Phase II EI.

Table 16: Relative Distribution of Blackened Acres by Fire Severity Category
"SD" indicates one standard deviation, and "---" means not calculated due to a sample size of one.

		Severity Class (Percent of Blackened Acres ± SD)		
NFDRS	Sample Size	Low	Moderate	High
A	3	21 ± 18	36 ± 31	43 ± 49
B	2	26 ± 29	31 ± 14	43 ± 43
C	5	25 ± 22	31 ± 29	44 ± 31
F	4	36 ± 27	34 ± 25	30 ± 19
G	1	15 ± ---	74 ± ---	11 ± ---
H	5	33 ± 24	38 ± 21	29 ± 16
L	1	2 ± ---	17 ± ---	81 ± ---
R	3	14 ± 25	18 ± 15	68 ± 36
T	1	14 ± ---	68 ± ---	18 ± ---
U	4	27 ± 18	36 ± 12	37 ± 28
ALL	**29**	**25 ± 21**	**35 ± 22**	**40 ± 29**

2.5.3 Spatial, Temporal, and Fuel Model Refinements

2.5.3.1 Spatial Refinements

Based on the information gathered on the large fire events, as summarized in Table 16, several refinements were applied. A spatial check was performed for the largest fires and fire complexes for which digital, GIS-based, fire perimeters were available. The fire locations of these fires in the Phase I EI (Table 16) were plotted on the same map as the GIS-based final fire perimeters and checked for accuracy. The Phase I EI fire locations were consistent with the GIS perimeters for all events, and no changes in the location data for these files were implemented.

2.5.3.2 Temporal Refinements

The data gathered in the form of reports generally only provided the total (perimeter) acreage and the start and end date for each fire, while the GIS data only provided the final fire perimeters. Generally, the data already present in Phase I EI had a higher temporal resolution than either the reports or the GIS data. Thus, no temporal adjustments were made to the data.

2.5.3.3 Fuel Model Refinements

For a selection of the larger fires in the lower 48 states, the GIS-based final fire perimeters were used to extract the distribution of fuel models within the final perimeters. The fuel consumption was then recalculated based on the blackened acres, thereby taking into account the unburned portion within the fire perimeter. The fire perimeters were intersected with two fuel model maps, the NFDRS fuel model layer (using the WRAP's NFDRS fuel loading table) and a more detailed fuel characteristics class (FCC) layer (personal communication, Donald McKenzie, USFS, 6/25/04).

The comparison results presented in Table 17 indicate that adjusting the total consumption using a more refined GIS-based methodology can produce mixed results (resulting consumption can be either higher or lower than the consumption in the Phase I EI). Generally, the more spatially resolved fuel consumption technology yielded lower total consumption than the method used for the Phase I EI. An exception was fires with fuel model C (open ponderosa pine), coinciding with a fairly low fuel model loading in the Phase I EI. The higher spatial resolution method increased consumption for these fires by incorporating acreage with higher fuel loadings within the fire perimeter.

A separate, new (draft) default set of consumption percentages was developed for the FCC categories. Note that the FCC estimates did not include the consumption of duff, since the duff variable in the FCC data set was provided in terms of thickness (inches) rather than loading (tons per acre). Also, it was not clear from the FCC data if the crown mass was included in the loading, and if so, how to account for the specific crown consumptions as was done for the WRAP's NFDRS fuel consumption tables. The FCC analysis also produced mixed results. In all cases analyzed, the direction of fuel consumption changes was identical to the more refined NFDRS method. In general, the FCC analysis indicated slightly higher decreases in fuel consumption than the NFDRS method and considerably lower increases. Both fuel consumption refinement techniques that were analyzed (refined spatial NFDRS and FCC data) produced consistent results (i.e., both methods indicate a fuel consumption decrease for the same fires.) The decision was made to implement the final consumption refinement based on NFDRS data layer in the interest of maintaining the technical consistency of the Phase II EI system.

Table 17: Sensitivity of Estimated Fuel Consumption to Adjustment for Blackened Acres in Combination With Fuel Loading Based on GIS-Derived NFDRS and FCC Fuel Layers

Fuel consumption was based on default (WRAP) consumption percentages by fuel size class and held constant for each fire severity class.

	Phase I	Total Fuel Consumption (10^6 tons)			Delta Consumption (%)	
Fire Name	NFDRS	Phase I EI	NFDRS	FCC	NFDRS	FCC
Biscuit	G	21.73	11.07	7.68	-49	-65
Hayman	C	0.65	2.23	1.34	+244	+107
McNalley	B	2.94	2.67	0.72	-9	-75
Sanford	K	0.93	0.41	0.51	-56	-45
Ponil Complex	H	2.54	0.45	0.17	-82	-93
Missionary Ridge	C	0.31	0.97	0.40	+211	+28
Rattle	G	4.11	0.95	0.34	-77	-9

2.5.3.4 Additional Fuel Consumption Refinements

In addition to fire perimeter information, fire severity information was available for a subset of wildfire and fire complexes (either based on reports or GIS-layers). This information was used to further refine fuel consumption estimates by defining variable fuel consumption percentages by fuel size class for each reported fire severity category (low, moderate, and high severity: Tables 19 and 20). Based on the FCC overlay, this additional refinement decreased the total fuel consumption somewhat compared to the process where all burned acres received a default consumption percentage (Table 18). Based on the NFDRS overlay this additional refinement had variable effects, varying from a decrease to an increase of the estimated consumption compared to application of default consumption percentages. However, overall the additional refinement of adding fire severity levels did not lead to statistically different changes in consumption (Paired T-test, t_{13}=0.465, P=0.650). No changes in the fuel consumption data were made based on fire severity information.

Table 18: Sensitivity of Estimated Fuel Consumption to Adjustment for Blackened Acres in Combination With Fuel Loading Based on GIS-Derived NFDRS and FCC Fuel Layers

Fuel consumption was based on variable consumption percentages by fuel size class and fire severity class.

	Phase I	Total Fuel Consumption (10^6 tons)			Delta Consumption (%)	
Fire Name	NFDRS	Phase I EI	NFDRS	FCC	NFDRS	FCC
Biscuit	G	21.73	6.22	4.78	-71	-78
Hayman	C	0.65	1.82	1.07	+181	+65
McNalley	B	2.94	2.26	0.60	+23	-80
Sanford	K	0.93	0.35	0.39	+62	-58
Ponil Complex	H	2.54	0.29	0.09	-89	-96
Missionary Ridge	C	0.31	0.82	0.39	+163	+25
Rattle	G	4.11	0.82	0.26	-80	-94

2.5.3.5 Results of Spatial, Temporal, and Fuel Model Refinements Analyses

- The data available did not allow for spatial improvement over the temporal course of the fire, nor for data quality improvements of daily acres. The spatial accuracy of the Phase II EI data was checked for those wildfires for which GIS-based fire perimeters were available.
- Refinement of fuel model information for the large fires was performed for those fires with available GIS-based fire perimeters (Table 18) by overlaying the perimeters with the NFDRS fuel model layer. This is consistent with the use of NFDRS for fuel loadings generally in the 2002 emission inventory.
- Refinement of fuel model adjustments by distinguishing different fuel consumption levels by fire severity category was not implemented.

Table 19: Summary of Fuel Consumption Percentages Applied to Model Variable Consumption by Fire Severity Class, NFDRS Fuel Models

Default percentages applied in Phase I EI.

Fuel Size Class	Default Consumption	Low Fire Severity	Moderate Fire Severity	High Fire Severity
1-hour	100%	100%	100%	100%
10-hour	100%	100%	100%	75%
100-hour	100%	100%	75%	25%
1,000-hour	100%	100%	50%	0%
Wood	100%	100%	100%	50%
Herb	100%	100%	100%	100%
Duff	50%	100%	50%	0%
Crown	62%	100%	40%	0%

Table 20: Summary of Fuel Consumption Percentages Applied to Variable Consumption by Fire Severity Class, FCC Fuel Models

Default percentages serve as temporary placeholder.

Fuel Size Class	Default Consumption	Low Fire Severity	Moderate Fire Severity	High Fire Severity
1-hour	100%	100%	100%	100%
10-hour	100%	75%	100%	100%
100-hour	100%	25%	75%	100%
1,000-hour	100%	0%	50%	100%
10,000-hour	50%	0%	25%	100%
>10,000-hour	25%	0%	10%	100%
Grass	100%	100%	100%	100%
Shrub	100%	50%	100%	100%
Duff *	0%	0%	0%	0%

* Duff consumption was set to zero for all fire categories, since data were provided in terms duff depth and not in actual loading.

2.5.4 Overall Assessment of Refinements

Table 21 summarizes the potential changes to the data that have resulted from incorporating the refinements discussed in this section. The number of fire events, number of fire days, fire acres, and fuel consumption are shown in Table 21. The number of fire events and the number of fire days only changed based on the duplicate fire checking in the fire complexes. While the change in numbers of fire events and fire days was relatively small, the duplicate checking decreased the fire acres and the fuel consumption by 4 to 5 percent from the Phase I EI. An additional reduction in fire acres and fuel consumption was achieved by adjusting the acreage for the largest fire events from perimeter acres to blackened acres. The combined removal of the duplicate fire entries and the blackened acreage adjustment reduced the fuel consumption by almost 10 percent. An additional 3 to 9 percent reduction was achieved based on the fuel model refinements of those large fires for which GIS-based perimeter data were available.

Table 21: Summary of Estimated Adjustments to the Phase II EI (Wildfire and Wildland Fire Use) Based on Described Quality Control and Data Refinement Procedures

The percentages in parentheses refer to the change as a percent of the Phase I EI.

Adjusted records by Refinement Step	# of Fire Events	# of Fire Days	Fire Acres	Fuel Consumption (10^6 tons)
Phase I EI[1]	1,899	3,243	6,366,532	178.1
Fire complex duplicates	26 (-1.4%)	74 (-2.2%)	259,603 (-4.1%)	8.1 (-4.5%)
Blackened acres	As above	As above	342,199 (-5.4%)	8.9 (-5.0%)
NFDRS, default consumption[2]	As above	As above	As above	15.2 (-8.5%)
FCC, default consumption[2]	As above	As above	As above	21.2 (-12.0%)
NFDRS, severity class specific consumption[2]	As above	As above	As above	19.9 (-11.2%)
FCC, severity class specific consumption[2]	As above	As above	As above	23.9 (-13.4%)
Overall Adjustments	**26 (-1.4%)**	**74 (-2.2%)**	**601,802 (-9.5%)**	**23.3 to 32.0 (-13.0% to -18.0%)**

1 References values were based on data before incomplete records were dropped from EI, and did not include smoldering. Hence, the data are somewhat different from those in the final Phase II EI.

2 These adjustments and percentages did include the correction for blackened acres as well as the fuel models.

2.6 Wildland Fire Quality Control Process

After implementing the technical refinements described in Section 2.5, a quality control (QC) process was implemented to allow for review of wildfire and prescribed fire data by state, tribal, and federal agencies. The intent of the QC process was to present wildland fire data to those presumed to be "closest" to the fire activity data, obtain a critical review of the activity data, and incorporate any recommended changes to the data. Through this process, the FEJF sought to increase the accuracy of the Phase II EI and to increase the confidence of the WRAP, States, Tribes, and Federal Land Managers (FLMs) in the use of the Phase II EI in regional haze modeling.

2.6.1 QC Binder Summary

Hardcopy binders were mailed to representatives of states, Tribes, and FLMs in the WRAP-Region to quality control the Phase II EI activity data. These binders featured wildfire and/or prescribed burning summaries and fire event level data specific to the jurisdiction of the recipient. The binders included tables and charts summarizing activity data, feedback forms to recommend changes to the fire events in the inventory, and a documentation section including a previous version of this report. The binders also included instructions on how to download the entire emission inventory database to perform a more thorough QC if desired.

The binders sent to states and Tribes included wildfire, prescribed, and WFU burning activity data. GACC FLMs received data for wildfire and WFU only, while all other FLMs received only prescribed fire and WFU data. Table 22 summarizes the binders sent and the responses received.

Table 22: Summary of Wildland Fire QC Binders Sent and QC Feedback Received

Agency	% Response	QC Binders Sent Out	QC Feedback Received	No Change	New Data
BLM	55	12	7	3	4
FWS	50	5	2	1	1
GACC	33	9	3	1	2
NPS	0	5	0	0	0
USFS	33	6	2	1	1
States	75	16	12	7	5
Tribes	0	5	0	0	0

2.6.2 Feedback Response Summary

The overall response rate for FLMs was 37 percent and for states was 75 percent. Table 23 shows the breakdown of responses by agency. Of the 26 QC responses received, 13 confirmed that the data was representative of actual burning activity and did not recommend any changes. Thirteen reviewers submitted new or revised data for the 2002 Emission Inventory. Overall, the QC process resulted in a documented review by states of 92 percent of all Phase II EI acres and 24 percent by FLMs of all Phase II EI acres.

A summary of changes to the burning activity data due to QC responses are also presented in Table 23. Types of changes included adding events, removal of events, and revision of event acres, fuel loading and/or revised location data.

The most significant QC changes to the data were from the submission of new data sets. Arizona and Wyoming submitted new data for prescribed fire for 2002. This new data replaced the existing prescribed fire data for those states. Another major new data set was a WRAP-wide prescribed fire database for BLM prescribed and WFU fires. Comparing this data with existing BLM fire data showed some similarities and some differences. In cases that a BLM regional office did not provide a response to a QC packet, data from the BLM's WRAP-wide prescribed fire database was used.

Air Sciences Inc. implemented internal QC checks when incorporating new data into the database. Reported new fires were checked against existing data to see if they were already in the database. Some of the existing fire events were updated with new information, while others were removed and replaced with new data.

Table 23: Detail of Wildland Fire QC Binder Feedback Received

Agency	Region	Contact Person	Returned Form A	Submitted New Data	Response Incomplete	Data Submitted by (if different than Contact Name)	Comments	Acres Reviewed
BIA	All Regions	Beverly Schwab			x			20,644
BLM	Alaska	Susan Christensen			x			159,627
BLM	All Regions	Paul Schlobohm		x			Paul has more complete BLM Rx fire database	89,688
BLM	Arizona	McKinley-Ben Miller	x				No Change	10,801
BLM	California	Craig Barnes	x				No Change	903
BLM	Colorado	Marcus Schmidt		x			submitted excel file with corrections and new activity	1,791
BLM	Idaho	Christa Gollnick-Wade	x				No Change (also, we misspelled Krista and Waid)	43,496
BLM	Montana	Jim Grey			x			5,933
BLM	Nevada	Kevin Hull		x			faxed comments to Chet Sergent, who forwarded to us	4,855
BLM	New Mexico	Lisa Bye	x	x			filled out Forms A & B and returned entire binder	575
BLM	Oregon	Jim Russell			x			17,297
BLM	Utah	Greg Zschaechner			x			2,828
BLM	Wyoming	John Glenn			x			1,209
FWS	All Regions	Dennis Haddow			x			40,716
FWS	Region 1	John Holcomb	x	x			submitted hard copy of marked up FF B	27,967
FWS	Region 2	Tricia Roller			x			515
FWS	Region 6	Jim Kelton			x			11,199
FWS	Region 7	Karen Murphy				Mary Kwart	emailed comments, but no FFA or B	1,035
GACC	Alaska	Susan Christensen			x			1,950,087
GACC	Eastern Great Basin	Deb Bower	x	x			returned FF's A&B marked up, attached additional fire data	312,225
GACC	Northern California	Mike Lococo			x			46,770
GACC	Northern Rockies	Colleen Finneman	x			Dzomba (USFS Northern)	Northern)	147,547
GACC	Northwest	Mike Fitzpatrick			x			1,023,250
GACC	Rocky Mountain	Gwenan Poirier	x	x			mailed feedback as a hard copy	706,837
GACC	Southern California	Kim Bolan			x			410,882
GACC	Southwest	Chuck Maxwell			x			806,124
GACC	Western Great Basin	Kathrin Wiegard			x			112,392
NPS	Intermountain	Brandie Litreal			x			13,808
		Aaron Worstell			x			
		Mike Wallace			x			
NPS	Midwest	Scott Beacham			x			6,328
NPS	Pacific West	Barbara Rice			x	Christie Neill	Christie is still going through the data	10,276
USFS	Intermountain (R4)	Bud Rolofson			x			34,978
USFS	Northern (R1)	Thomas Dzomba	x	x			electronic copy of FF B with changes	45,475
USFS	Pacific Northwest (R6)	Jim Russell			x			47,358
USFS	Pacific Southwest (R5)	Aaron Globter	x			Ricardo Cisneros	No Change	46,876
USFS	Rocky Mountain (R2)	Paul Langowski			x			40,326
USFS	Southwestern (R3)	Christi Gordon			x		Saraj says Christi responded and had no changes. We have no record of her response	39,543

Table 23: Detail of Wildland Fire QC Binder Feedback Received – continued

State	Dept.	Contact Person	Returned Form A	Submitted New Data	Response Incomplete	Data Submitted by (if different than Contact Name)	Comments	Acres Reviewed
Alaska	AQ	Tom Chapple				Ron King	No Change	1,951,195
Arizona	AQ	Ira Domsky			x			
		Mark Fitch		x			sent new raw data for AZ to replace existing data	609,884
California	Forestry	Jim Wright	x			Jeff Stephens	No Change	601,575
Colorado	Forestry	Rich Homann	x			Vaughn Jones	No Change	452,529
	AQ	Coleen Campbell			x			
Idaho	Forestry	Brian Shiplett	x				No Change	170,662
Montana	Forestry	Bob Harrington			x			190,032
Nevada	AQ	Chet Sergent	x				No Change	71,102
New Mexico	Forestry	Nancy Neskauskus			x			277,431
North Dakota	AQ	Gene Nelson	x				No Change	110,607
Oregon	Forestry	Mike Ziolko	x	x			faxed FF A, B & C with updates	1,055,279
South Dakota	AQ	Rick Boddicker	x				No Change (3 records dropped per WY feedback - dups)	87,195
Utah	AQ	Greg Zschaechner	x	x			sent spreadsheet with new data	266,617
Washington	Forestry	Darrel Johnston		x			sent new data 2/16	123,815
Wyoming	AQ	Darla Potter	x	x			Darla responded to our comments about WY data	182,579

SECTION 3

THE 2002 AGRICULTURAL BURNING EMISSION INVENTORY

For the Phase II EI, an agricultural burning emission inventory representative of 2002 was created for the 13-states in the WRAP region (Hawaii is not included in the agricultural burning EI).

3.1 Agricultural Burning Activity Data

3.1.1 Data Sources

The agricultural burning activity data source for each state fell into two general categories:

- Raw activity data collected under this contract by soliciting state agencies.
- Activity data carried over from the WRAP 2018 Base Smoke Management Scenario emission inventory created for the 2018 projections.

All states supplied 2002 activity data under this contract except for Alaska, Arizona, Nevada, and North Dakota. Idaho submitted new activity data for ten counties and requested that 2018 Base Smoke Management Scenario figures be carried over for the remainder of the state.

For a complete description of the WRAP 2018 Base Smoke Management Scenario emission inventory, please see:

- The report entitled *Non-Burning Management Alternatives on Agricultural Lands in the Western United States* (Eastern Research Group, Inc. and Enviro-Tech Communications, 2002), prepared for the Fire Emissions Joint Forum of the WRAP. The report emission included an inventory of agricultural burning activity data for the 13 states in the modeling domain.
- The report entitled *Integrated Assessment Update and 2018 Emissions Inventory for Prescribed Fire, Wildfire, and Agricultural Burning* (Air Sciences Inc., Draft 2002), prepared for the Fire Emissions Joint Forum of the WRAP. This report describes the preparation of the model-ready emission inventory and creation of smoke management scenarios.

3.1.2 Agricultural Burning on Tribal Lands

No agricultural burning activity data was available from tribal governments. The agricultural burning activity database does not necessarily include quantification of burning on tribal lands, although data collected from states may include burning in Indian Country. In this section of the document, the term "state" refers to the entire geographic area within the exterior boundary of a state.

When surveyed by ERG, nearly 60 percent of the Tribes that conducted prescribed burning reported the existence of agricultural burning. However, the data provided in the survey responses were not of sufficient detail to quantify burning activities. For a more complete description of the findings of the ERG data gathering efforts with regard to burning on tribal lands, please see the report entitled *Non-Burning Management Alternatives on Agricultural Lands in the Western United States* (Eastern Research Group, Inc. and Enviro-Tech Communications, 2002).

3.1.3 Time Periods of the Actual Agricultural Burning Data

Agricultural burning activity data in the database included data for 1996 through 2003. Priority was given to 2002 data because that is the year of the crop production data and the WRAP emission inventory base year. However, in order to provide data for as large a geographic area as possible, it was necessary to use other years if 2002 data did not exist or were known to be largely incomplete compared to later years. Importantly, each of the state-specific 13 data sets included in the database are believed to represent a single calendar year of agricultural burning data. Therefore, when combined, the data sets should represent a single year of agricultural burning activity.

3.1.4 Data Quality Requirements

Minimum data quality requirements were established for activity data to be eligible for use in the emission inventory. Specifically, to be eligible, a record had to have a valid date field (either a specific date [daily] or a specific month), a valid state name, a valid county name, and a valid value in the residue-loading field. A record with either missing or invalid data in any of these fields was flagged as invalid and not used in the emission inventory.

3.2 Fuel Loading and Emission Factors for Agricultural Burning

Fuel loading and emission factors were provided by the FEJF and its Alternatives to Agricultural Burning Task Team. Fuel loading and emission factors are presented in Table 24 and originate from data peer-reviewed by the ETT. Several crops identified in the Phase II agricultural burning activity were not included in the fuel loading and emission factors provided by the FEJF (indicated with an asterisk in Table 24). In these instances, fuel loading and emission factors were assigned from comparable crops.

The pollutant-specific emission factors (in pounds of pollutant per ton of residue burned) are multiplied by the residue loading values (tons residue burned) in the agricultural burning activity database to calculate emissions.

Table 24: Agricultural Burning

Crop Type	Residue Loading (ton/acre)	Emission Factors by Pollutant (lbs pollutant/ton residue)											
		PM	PM10	PM2.5	EC	OC	VOC	CH4	NH3	NOx	CO	SO2	PMC
almonds	1	8.72	8.60	8.20	2.15	3.70	8.90	2.34	1.28	7.24	63.86	0.12	0.40
apples	2.3	8.55	8.39	7.96	2.10	3.61	4.95	3.73	1.81	11.18	90.32	0.22	0.43
apricots	1.8	9.07	8.90	8.45	2.22	3.83	6.94	5.24	1.48	7.84	73.91	0.15	0.45
asparagus	1.5	32.94	32.40	30.90	8.10	13.93	14.99	11.32	2.72	5.02	135.88	0.67	1.50
avocado	1.5	29.69	29.14	27.44	7.28	12.53	26.17	19.76	3.28	7.36	164.07	0.14	1.70
barley	1.7	15.52	15.36	14.86	2.46	6.14	23.34	4.94	3.95	5.44	197.34	0.08	0.50
beans; all dry edible	2.5	15.72	15.46	14.67	3.87	6.65	16.03	12.10	3.34	5.87	167.04	0.11	0.79
blueberries	1.7	18.02	17.73	16.95	4.43	7.62	11.93	9.01	2.54	5.02	127.09	0.67	0.78
bushberry	1.7	18.02	17.73	16.95	4.43	7.62	11.93	9.01	2.54	5.02	127.09	0.67	0.78
canola	1.3	18.02	17.73	16.95	4.43	7.62	11.93	9.01	2.54	5.02	127.09	0.67	0.78
cherries	1	12.62	12.38	11.60	3.10	5.32	9.40	7.10	1.38	8.15	68.97	0.16	0.78
citrus	1	8.50	8.35	7.92	2.09	3.59	9.62	7.26	2.29	7.36	114.57	0.14	0.42
coffee	1	11.16	10.96	10.25	2.74	4.71	8.85	6.68	1.85	7.30	92.70	0.14	0.70
corn; for grain*	4.2	12.62	12.42	11.96	1.86	4.35	9.12	3.50	1.55	3.64	77.56	0.40	0.46
corn; for silage	0	12.62	12.42	11.96	1.86	4.35	9.12	3.50	1.55	3.64	77.56	0.40	0.46
cotton; amer. pima	1	18.02	17.73	16.95	4.43	7.62	11.93	9.01	2.54	5.02	127.09	0.67	0.78
cotton; upland	1	18.02	17.73	16.95	4.43	7.62	11.93	9.01	2.54	5.02	127.09	0.67	0.78
CRP	2.6	18.02	17.73	16.95	4.43	7.62	11.93	9.01	2.54	5.02	127.09	0.67	0.78
dates	1.7	11.52	11.30	10.73	2.83	4.86	4.38	3.31	1.29	6.00	64.59	0.12	0.58
ditches and ditch banks	3.2	18.02	17.73	16.95	4.43	7.62	11.93	9.01	2.54	5.02	127.09	0.67	0.78
ditches and fenceline	1.6	18.02	17.73	16.95	4.43	7.62	11.93	9.01	2.54	5.02	127.09	0.67	0.78
figs	0.75	10.06	9.87	9.30	2.47	4.24	8.58	6.48	1.63	7.44	81.55	0.14	0.57
filberts*	1.7	11.16	10.96	10.25	2.74	4.71	8.85	6.68	1.85	7.30	92.70	0.14	0.70
flaxseed*	1.7	18.02	17.73	16.95	4.43	7.62	11.93	9.01	2.54	5.02	127.09	0.67	0.78
fruits and vegetables; other	2	11.16	10.96	10.25	2.74	4.71	8.85	6.68	1.85	7.30	92.70	0.14	0.70
grapes	1.47	7.29	7.15	6.72	1.79	3.08	5.55	4.19	1.49	7.59	74.45	0.15	0.44
hay; alfalfa	2.5	32.34	31.81	30.36	7.95	13.68	24.22	18.29	2.66	5.02	132.81	0.67	1.45
hay; all	0.8	32.34	31.81	30.36	7.95	13.68	24.22	18.29	2.66	5.02	132.81	0.67	1.45
hay; all other	0.8	32.34	31.81	30.36	7.95	13.68	24.22	18.29	2.66	5.02	132.81	0.67	1.45
hops	0.8	18.02	17.73	16.95	4.43	7.62	11.93	9.01	2.54	5.02	127.09	0.67	0.78
kiwi	1.9	11.16	10.96	10.25	2.74	4.71	8.85	6.68	1.85	7.30	92.70	0.14	0.70
lentils	1.7	18.02	17.73	16.95	4.43	7.62	11.93	9.01	2.54	5.02	127.09	0.67	0.78
macadamia nuts	2.5	11.16	10.96	10.25	2.74	4.71	8.85	6.68	1.85	7.30	92.70	0.14	0.70
mint	1.7	18.02	17.73	16.95	4.43	7.62	11.93	9.01	2.54	5.02	127.09	0.67	0.78
nectarines	0.5	5.84	5.74	5.44	1.43	2.47	3.38	2.55	0.97	7.65	48.53	0.15	0.29
oats	1.7	23.28	22.90	21.79	5.72	9.85	11.39	8.60	3.01	4.98	150.44	0.66	1.11
olives	1.6	18.08	17.74	16.69	4.44	7.63	15.49	11.69	3.43	7.82	171.43	0.15	1.05
onion seeds	1.7	18.02	17.73	16.95	4.43	7.62	11.93	9.01	2.54	5.02	127.09	0.67	0.78
orchard pruning; unspecified	1.7	11.16	10.96	10.25	2.74	4.71	8.85	6.68	1.85	7.30	92.70	0.14	0.70
orchard removal	15	11.16	10.96	10.25	2.74	4.71	8.85	6.68	1.85	7.30	92.70	0.14	0.70
peaches	2.5	7.13	7.00	6.64	1.75	3.01	3.56	2.69	1.00	6.17	49.82	0.12	0.36
peanuts	1.2	18.02	17.73	16.95	4.43	7.62	11.93	9.01	2.54	5.02	127.09	0.67	0.78
pears	2.6	13.65	13.39	12.63	3.35	5.76	7.76	5.86	1.74	7.91	86.76	0.15	0.76
peas; dry edible	2.5	15.72	15.46	14.67	3.87	6.65	16.03	12.10	3.34	5.87	167.04	0.11	0.79
pecans	1.7	11.16	10.96	10.25	2.74	4.71	8.85	6.68	1.85	7.30	92.70	0.14	0.70
persimmons	1.7	11.16	10.96	10.25	2.74	4.71	8.85	6.68	1.85	7.30	92.70	0.14	0.70
pistachio	1.7	11.16	10.96	10.25	2.74	4.71	8.85	6.68	1.85	7.30	92.70	0.14	0.70
plums and prunes	1.2	3.96	3.88	3.75	0.97	1.67	6.16	4.65	1.26	6.96	62.92	0.13	0.13
pomegranates*	1.7	11.16	10.96	10.25	2.74	4.71	8.85	6.68	1.85	7.30	92.70	0.14	0.70
potatoes	1.2	18.02	17.73	16.95	4.43	7.62	11.93	9.01	2.54	5.02	127.09	0.67	0.78
proso millet	1.9	18.02	17.73	16.95	4.43	7.62	11.93	9.01	2.54	5.02	127.09	0.67	0.78
quinces*	1.7	11.16	10.96	10.25	2.74	4.71	8.85	6.68	1.85	7.30	92.70	0.14	0.70
rice; all	3	6.98	6.92	6.44	1.25	1.38	6.74	1.44	1.26	5.68	62.78	1.24	0.48
rye	1.9	18.02	17.73	16.95	4.43	7.62	11.93	9.01	2.54	5.02	127.09	0.67	0.78
safflower	1.3	20.95	20.61	19.67	5.15	8.86	17.23	13.01	3.35	5.24	167.64	0.70	0.93
seeds; alfalfa*	0.8	32.34	31.81	30.36	7.95	13.68	24.22	18.29	2.66	5.02	132.81	0.67	1.45
seeds; KBG	2	18.02	17.73	16.95	4.43	7.62	11.93	9.01	2.54	5.02	127.09	0.67	0.78
seeds; other	2	18.02	17.73	16.95	4.43	7.62	11.93	9.01	2.54	5.02	127.09	0.67	0.78
seeds; unspecified*	2	18.02	17.73	16.95	4.43	7.62	11.93	9.01	2.54	5.02	127.09	0.67	0.78
sorghum*	2.9	21.74	21.38	20.41	5.34	9.19	6.16	4.65	1.86	5.43	93.00	0.72	0.97
soybeans*	1	18.02	17.73	16.95	4.43	7.62	11.93	9.01	2.54	5.02	127.09	0.67	0.78
sudan*	2	18.02	17.73	16.95	4.43	7.62	11.93	9.01	2.54	5.02	127.09	0.67	0.78
sugarbeets*	1	18.02	17.73	16.95	4.43	7.62	11.93	9.01	2.54	5.02	127.09	0.67	0.78
sugarcane	14	11.22	10.86	9.98	1.63	4.02	3.68	0.82	1.02	2.80	50.96	1.24	0.88
sunflower	1	18.02	17.73	16.95	4.43	7.62	11.93	9.01	2.54	5.02	127.09	0.67	0.78
various weeds and ditch banks*	1	18.02	17.73	16.95	4.43	7.62	11.93	9.01	2.54	5.02	127.09	0.67	0.78
walnuts*	1.2	6.44	6.30	5.92	1.83	2.96	9.30	3.28	2.00	6.78	100.08	0.28	0.38
wheat; all	1.9	11.64	11.48	10.88	1.61	4.36	10.84	3.64	2.67	4.66	133.38	0.94	0.60
wheat; durum	1.9	11.64	11.48	10.88	1.61	4.36	10.84	3.64	2.67	4.66	133.38	0.94	0.60
wheat; other spring	1.9	11.64	11.48	10.88	1.61	4.36	10.84	3.64	2.67	4.66	133.38	0.94	0.60
wheat; other spring (irrigated)	4	11.64	11.48	10.88	1.61	4.36	10.84	3.64	2.67	4.66	133.38	0.94	0.60
wheat; unspecified*	1.9	11.64	11.48	10.88	1.61	4.36	10.84	3.64	2.67	4.66	133.38	0.94	0.60
wheat; winter all*	1.9	11.64	11.48	10.88	1.61	4.36	10.84	3.64	2.67	4.66	133.38	0.94	0.60
unspecified	--	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CARB average field crop	2.6	9.01	8.86	8.47	2.22	3.81	5.96	4.50	1.27	2.51	63.55	0.33	0.39
other ag burning*	2.6	9.01	8.86	8.47	2.22	3.81	5.96	4.50	1.27	2.51	63.55	0.33	0.39
CO average field crop*	4.2	12.62	12.42	11.96	1.86	4.35	9.12	3.50	1.55	3.64	77.56	0.40	0.46
Idaho Crop N/A*	2	18.02	17.73	16.95	4.43	7.62	11.93	9.01	2.54	5.02	127.09	0.67	0.78
berries; other*	1.3	20.95	20.61	19.67	5.15	8.86	17.23	13.01	3.35	5.24	167.64	0.70	0.93

*These crops do not have unique emission factors but are associated with emission factors for other crops.

3.3 Temporal Refinement of Agricultural Emissions Data

Approximately 1,300 records in the agricultural database were temporally resolved to the month (i.e., total residue of a specific crop burned in a county in a month). The WRAP modeling requires that emissions data be temporally resolved to the day. The following techniques were employed to break the monthly data into daily data.

First, by the emission calculation methods described above, monthly emissions were calculated (i.e., tons of a specific pollutant due to the burning of a specific crop in a specific county in a specific month). Then, monthly emissions were broken into daily emissions in discrete "packets." The $PM_{2.5}$ packet size ranges from the plume characteristic table derived for the prescribed fire emission inventory were used here to assign a plume class number to each of the daily records in the agricultural emissions database. The $PM_{2.5}$ packet ranges are shown in Table 25.

Table 25: Plume Class Sizes

Plume Class	Low End of Range (tons $PM_{2.5}$)	High End of Range (tons $PM_{2.5}$)
1	0	1
2	>1	10
3	>10	100
4	>100	500
5	>500	NA

Each daily agricultural fire event is assigned a plume category (1 through 5). The probability of occurrences for the plume classes for the daily agricultural fires in the database was taken from the report entitled *Integrated Assessment Update and 2018 Emissions Inventory for Prescribed Fire, Wildfire, and Agricultural Burning* and were originally calibrated on daily data collected for that project. These probabilities were used to break the monthly agricultural burning emissions for each county into representative daily fire size packets. The statistics (number of events and probability of occurrence) for the final emission inventory are also shown in Table 26.

Table 26: Distributions of Daily Events by Plume Class

Plume Class	Events in 2018 Daily Data	Probability of Occurrence in 2018 Daily Data	Packet Fire Size (tons $PM_{2.5}$)	Events in Phase II EI	Probability of Occurrence in Phase II EI
1	47,056	0.975	0.064	99,485	.939
2	1,158	0.024	2.202	5,886	.056
3	35	0.0007	16.641	620	.006
4	0	0.0	NA	0	0.0
5	0	0.0	NA	0	0.0
Total	48,249			105,991	

3.3.1 Blackout Dates

Each daily event is assigned to a specific day of the month. Blackout days on which daily packets would not be assigned were taken from the *Integrated Assessment* report. Under that contract, the daily agricultural activity data was analyzed to determine if patterns of temporal distribution within months exist. The daily frequencies of events appeared to be uniformly distributed throughout the month except for obvious "no-burn" periods, primarily occurring before and/or on and/or after holiday periods and perhaps during brief periods of harvesting in late August. The daily events were randomly assigned to any day of the month that was not a "blackout" date, as identified in Table 27.

Table 27: Blackout Days for Agricultural Burning

Month	Days(s)	Holiday
January	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	New Year's Day
July	4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14	Fourth of July
August	21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31	Harvesting period
November	29	Thanksgiving
December	19, 20, 21, 22, 23, 24, 25, 26	Christmas

Upon the conclusion of the temporal allocation of the monthly emissions, the emission inventory included approximately 92,500 daily event records directly from the agricultural database and approximately 14,000 daily event records derived from the approximately 1,300 monthly activity records for a total of approximately 106,500 events in the inventory. Each produced daily fire event was entered in the emission inventory along with its emissions and associated plume characteristics.

3.4 Spatial Refinement of Agricultural Emissions Data

As described above, the emission inventory included actual daily agricultural burning events from the database and realistically-sized daily burning events created from monthly records in the activity database. All daily events in the activity database were resolved to the county level. To spatially allocate the daily events that did not have a source-supplied coordinate (including all the daily allocated events) to a 1-km resolution, the events were each assigned a coordinate location within the identified county on a stratified random basis.

The location of each agricultural burning event in the inventory was expressed by state and county identifiers (state/county name and state/county FIP code). Each fire was allocated according to its state and county identifiers in space. A map of counties was obtained from the National Atlas, and a LCC map showing agricultural cover types was used. Overlaying the two maps yielded a map of agricultural cover by county. The eligible pixels (agricultural cover) within each county could be looked up on this overlap map. The overlap map was recorded at a 1-km resolution. The individual fire events retained the state and county identifiers from their source database entry. For each fire event, the eligible 1-km cells were selected based on state/county identifier and agricultural cover type. In the event the LCC map did not indicate agricultural cover types occurring in the county, vegetated 1-km pixels in the county were selected. With the eligible 1-km cells selected, a single 1-km cell was then chosen at random. The coordinates of the 1-km grid cell were read and the latitude and longitude recorded to the fire event. In this fashion, every event in the daily agricultural burning emission inventory lacking a source-supplied location was given a coordinate.

3.5 Assigning Plume Characteristics to Agricultural Burning Events

The plume profile categories and calculations used for wildland fire (described above) were applied to agricultural burning events. The method to assign plume characteristics to agricultural burning events is very similar to the method for wildland fire (see Section 2.4). A diurnal consumption template was customized for agricultural burning.

3.5.1 Diurnal Consumption Template

For the agricultural burning emission inventory, like the 2018 prescribed fire emission inventory, the plume characteristics are based on fire size as a function of $PM_{2.5}$ emissions.

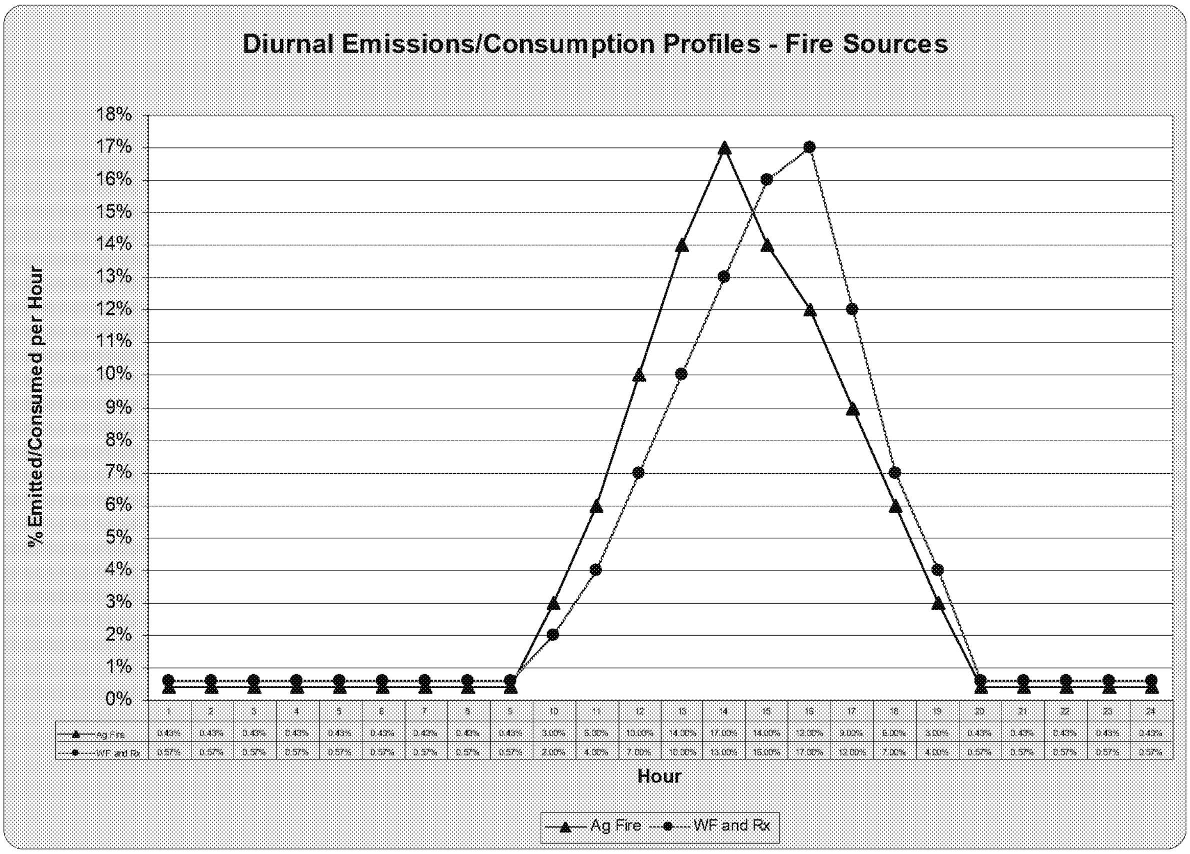
The WRAP Emissions and Modeling Forums requested hourly values of fire emissions and plume characteristics. To satisfy this temporal requirement, daily emissions for each agricultural burning event in the inventory were broken into hourly emissions using the agricultural burning diurnal consumption template (based on expert opinion) presented in Table 28.

Table 28: Diurnal Consumption Template Used to Distribute Emissions From Agricultural Burning (Percent Of Fuel Consumed Each Hour)

Hour	% Per Hour	Hour	% Per Hour
1	0.43	13	14.00
2	0.43	14	17.00
3	0.43	15	14.00
4	0.43	16	12.00
5	0.43	17	9.00
6	0.43	18	6.00
7	0.43	19	3.00
8	0.43	20	0.43
9	0.43	21	0.43
10	3.00	22	0.43
11	6.00	23	0.43
12	10.00	24	0.43

This diurnal consumption template varied from the template used for wildfire and prescribed fire in one important way: the daily emissions peak was moved to earlier in the day, largely due to the more consistent ignition times for agricultural fires (personal communication, Bryan Jenkins, UC Davis). The diurnal profiles for agricultural burning and wildfire/prescribed fire are shown graphically in Figure 10.

Figure 10: Diurnal Emissions/Consumption Profiles for Agricultural Burning and Wildfire/Prescribed Fire



3.5.2 Physical Plume Characteristics

Plume characteristics were assigned to each daily event using the same method employed for the wildland fire emission inventory. Table 29 presents the plume characteristics (buoyant efficiency [BE], height of the bottom of the plume [Pbot], and height of the top of the plume [Ptop]) to be assigned to each daily event according to the plume class of each event. Note, because there were no Class 4 or Class 5 agricultural burning events, the plume characteristics for these fire classes were not included in Table 29.

Table 29: Fire-Related Parameters as a Function of Fire Emission Classes

Class	1	2	3
Emissions (tons $PM_{2.5}$)	0 – 1	>= 1 – 10	>= 10 – 100
BE_{size}	0.40	0.60	0.75
Ptop max (m)	160	2,400	6,400
Pbot min (m)	0	900	2,200

3.6 Agricultural Burning Quality Control Process

3.6.1 QC Binder Summary

States and Tribes were given the opportunity to review and comment on agricultural burning activity data in the Phase II EI that was within their state or tribal lands. Binders were prepared that summarized data for each state and Tribe, and a CD was included that contained the entire agricultural burning database. An introductory letter was sent with the binders to explain the purpose for the QC review as well as to give instruction on how to conduct the review and submit a response.

3.6.2 QC Response Summary

Binders were sent to 16 state reviewers and 3 tribal reviewers, as shown in Table 30. Some states received more than one binder. There was no burning data in the inventory for Nevada, so a special packet was prepared for Nevada to provide agricultural burning activity data. Three of the states reviewed the data and responded that no changes were necessary, including Nevada, which responded that agricultural burning data was not available. Ten states submitted new or revised burning activity data. No new data was received from Tribes. Details of the responses received are given in Appendix A. Overall, the QC process resulted in documented review of agricultural burning for every state in the WRAP. The ETT determined that there was no agricultural burning in Alaska and, therefore, Alaska was omitted from the Phase II EI.

Table 30: Detail of Agricultural Burning QC Binder Feedback Received

State/Tribe	Contact Name	Agency	No Response	Returned Form A	Submitted New Data	Data Submitted by (if different than Contact Name)	Comments
AK							No ag QC packet was sent to Alaska
AZ	Marcia Colquitt	Arizona Department of Agriculture					Marcia feels unqualified to comment on data
	Randy Sedlacek	USFS c/o Arizona DEQ				Trevor Baggiore	Trevor is working with Randy to review data
CA	Neva Sotolongo	California Environmental Protection Agency			x		2000 statewide data & separate 2002 San Joaquin Valley data.
CO	James Sharkoff	USDA Natural Resource Conservation Service		x	x	Coleen Campbell	Sharkoff reports that no ag burning occurs in western CO. Coleen Campbell submitted new data, but it is annual summary.
ID	Diane Riley	Idaho Department of Environmental Quality			x		2003 event data for 10 counties:date, acres, location (TRS).
MT	John Coefield	Montana Department of Environmental Quality			x	James Carlin	New Ditch data: county, month, acres
NM	Lisa Bye	New Mexico Environmental Department			x	Rita Trujillo	Marked up dataset from packet: county, crop, month, acres
ND	Gene Nelson	North Dakota Health Department					Gene says data looks good (phone call 10/6/04)
NV	Chet Sergent	Nevada Dept of Env. Protection					*Special packet sent to NV at a later date. NV reports no new data
OR	Brian Finneran	Oregon Department of Environmental Quality		x	x	Jeffrey Stocum	2002 data: county, crop, acres, residue, temporal distribution, also includes some % burned info
	John Byers	Oregon Natural Resource Division		x			No changes
SD	Rick Boddicker	SD Department of Environment & Natural Resources			x		letter indicates very little burning in SD. Our solution: allocate 5,000 acres to eastern counties. Temporal same as Phase I.
UT	David McNeill	Utah Department of Environmental Quality			x	Aaron Chambers	2002 data: county, crop, acres, annual, a little general info on seasons when burning occurs
WA	Karen Wood	Washington State Department of Ecology			x		using 2003 data in place of 2002
	Dick Stendar	Washington State Department of Ecology	x				
WY	Darla Potter	Wyoming Department of Environmental Quality			x		submitted 2002 WISE data: county, crop, acres, monthly
Coeur d'Alene	Alene George	Lands Department	x				
Nez Perce	Julie Simpson	Air Quality Project Coordinator	x				
Spirit Lake	Frank Black Cloud	Air Programs Director	x				

SECTION 4

THE 2002 NON-FEDERAL PRESCRIBED RANGELAND BURNING EMISSION INVENTORY

For the Phase II EI an emission inventory of prescribed rangeland burning on non-federal lands in the WRAP region was prepared for 2002. In this section, rangeland burning is defined as prescribed fires on *non-federal* lands used for livestock grazing and ranching. Rangeland burning on federal lands was assumed to appear in the wildfire and prescribed burning activity data sources and corresponding emission inventories.

Event-level fire activity data for non-federal rangeland burning was not available for the entire WRAP region. This first WRAP rangeland burning emission inventory was designed to be complete for the WRAP region for 2002, albeit relying on expert opinion for total burning by state. This "base layer" was designed to accommodate superseding levels of detailed activity information as they become available. This layering concept was proposed as an alternative to the "gap-filling" method where trends observed in available specific data are used to fill the areas for which data is not available.

4.1 Rangeland Burning Activity Data

Rangeland burning activity data across the entire WRAP region was based on the Fire Emissions Joint Forum's assessment led by Pat Shaver of the USDA – Natural Resources Conservation Service (NRCS). Table 31 shows the FEJF estimate of acres burned by state. Burn activity was then pro-rated to the county level using acres of rangeland present in each county per the 1997 National Resources Inventory (NRI) CD-ROM Version 1 (December 2001) produced by the NRCS.

Table 31: Non-Federal Prescribed Rangeland Burning Activity by State

State	Acres Burned
AZ	250,000
CA	40,000
CO	12,000
ID	8,000
MT	150,000
ND	25,000
NM	60,000
NV	1,000
OR	300,000
SD	150,000
UT	25,000
WA	6,000
WY	15,000
Total	**1,042,000**

4.2 Temporal Allocation of Burn Activity

The temporal resolution of the rangeland burning activity for WRAP was supplied by the FEJF on an annual basis for 2002. Annual estimates of rangeland burning were allocated to the month according to FEJF instructions. The percent of activity per month used for the entire WRAP region is shown in Table 32.

Table 32: Percent Activity per Month for Non-Federal Rangeland Burning

Month	%-Annual
Jan	0
Feb	0
Mar	0.24
Apr	0.24
May	0.24
Jun	0.12
Jul	0
Aug	0
Sep	0.08
Oct	0.08
Nov	0
Dec	0
Total	**1.00**

4.3 Emission Calculations

Emissions per pollutant were calculated as activity (acres burned) multiplied by a fuel loading factor (ton/acre burned) and an emission factor (lb/ton) as shown in Equation 7. A fuel loading of 1.75 tons per acre was provided by Pat Shaver USDA – NRCS and accepted by the ETT to be representative of rangelands. The Conservation Reserve Program (CRP) suite of emission factors (derived from the California Air Resources Board's average of emission factors for field crops) were used to calculate emissions from rangeland burning activity. Fuel loading and emission factors for non-federal rangeland burning are show in Table 33.

Table 33: Rangeland Fuel Loading and Emission Factors

Fuel Loading	Emission Factors (Lbs Pollutant) / (Ton Biomass Consumed)											
Tons/Acre	PM	PM_{10}	$PM_{2.5}$	EC	OC	VOC	CH_4	NH_3	NO_x	CO	SO_2	PM C
1.75	18.02	17.73	16.95	4.43	7.62	11.93	9.01	2.54	5.02	127.09	0.67	0.78

$$\text{Tons Emissions} = \text{Acres Burned} \times \frac{\text{Tons Biomass}}{\text{Acres Burned}} \times \frac{\text{lbs Emissions}}{\text{Tons Biomass}} \times \frac{\text{Tons}}{2000\ \text{lbs}} \qquad \textbf{Equation 7}$$

4.4 Allocation of Emissions to Realistic Event Size and Day of Year

Emissions calculated per month were allocated into realistic fire size packets in a process similar to allocating agricultural fire emission into daily events. A suite of statistics of typical rangeland fire sizes and frequency distributions (probability of occurrence) by plume class were supplied by the FEJF and appear in Table 34. It was not possible to split the by-month by-county emissions exactly into the probabilities specified by the FEJF. Regardless, a fundamental distribution of events was achieved. This actual occurrence by plume class size is recorded in Table 34.

Table 34: Rangeland Burning Fire Size Packet Statistics

Plume Class	Low End of Range (tons $PM_{2.5}$)	High End of Range (tons $PM_{2.5}$)	Packet Fire Size (acres)	Packet Fire Size (tons $PM_{2.5}$)	Proposed Probability of Occurrence	Actual Occurrence in Daily Data
1	0	1	100	1.483	0.1	0.3
2	>1	10	200	2.966	0.6	0.6
3	>10	100	1,000	14.831	0.3	0.1

All fire events in a given month were assigned randomly to a day in that month. No blackout days were deemed applicable to the months in which rangeland burning was presumed to occur.

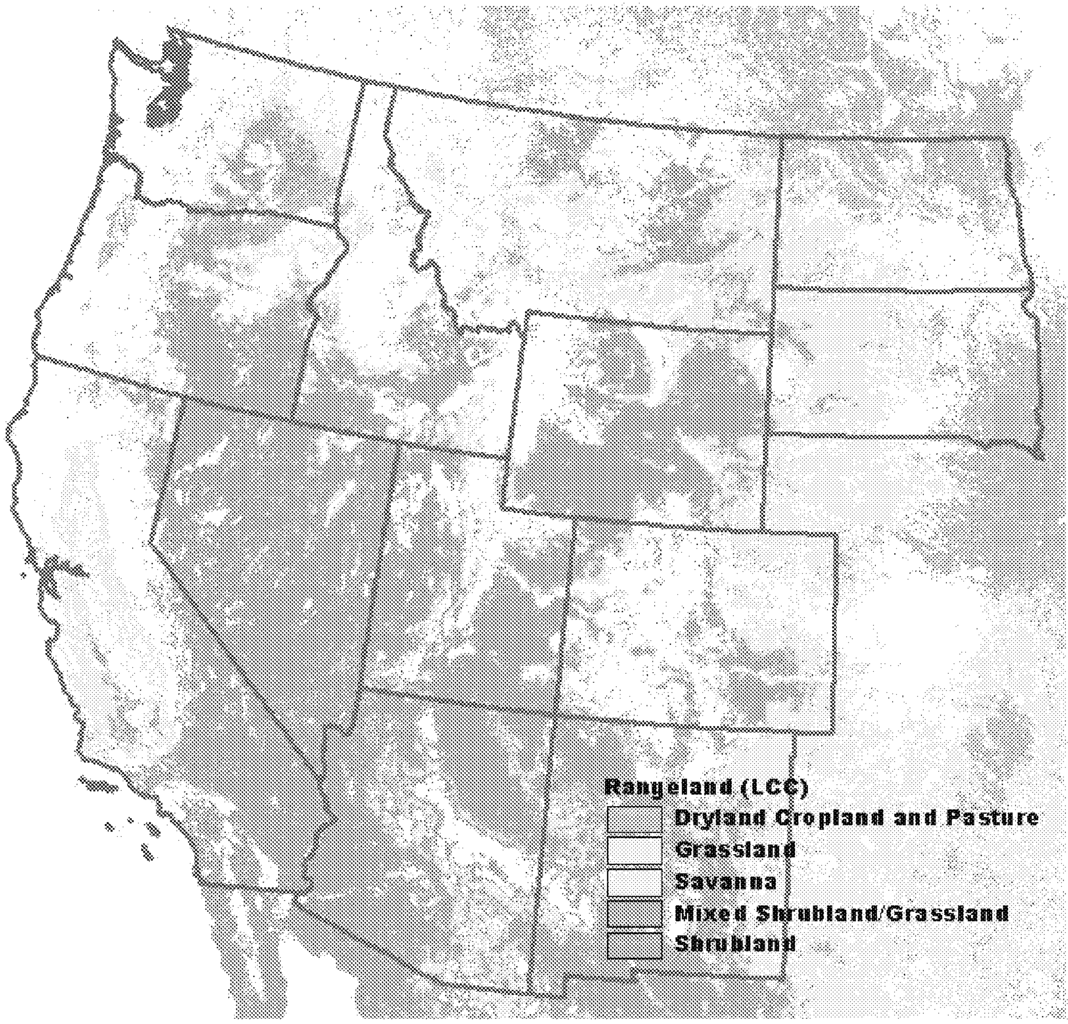
4.5 Allocation of Emissions to Coordinate Location

Daily burning events were located randomly within the county to portions considered to be rangeland, as mapped in the U.S. Geologic Service's Land Cover Characteristics (LCC) Database. LCCs are categorized per Table 35, and a corresponding map of rangeland is shown in Figure 11. The coordinate of the fire location was the centroid of a 1-km square LCC pixel randomly selected within the county.

Table 35: USGS Land Cover Characteristics Flagged as Rangeland

LCC Description	Rangeland?
Urban and Built-Up Land	-
Dryland Cropland and Pasture	Yes
Irrigated Cropland and Pasture	-
Cropland/Grassland Mosaic	-
Cropland/Woodland Mosaic	-
Grassland	Yes
Shrubland	Yes
Mixed Shrubland/Grassland	Yes
Savanna	Yes
Deciduous Broadleaf Forest	-
Evergreen Broadleaf Forest	-
Evergreen Needleleaf Forest	-
Mixed Forest	-
Water Bodies	-
Wooded Wetland	-
Barren or Sparsely Vegetated	-
Wooded Tundra	-
Mixed Tundra	-
Snow or Ice	-
254	-
Unlabelled Land Area	-

Figure 11: USGS Land Cover Characteristics Mapped as Rangeland



SECTION 5

RESULTS

5.1 Summary of 2002 Phase II Fire Emission Inventory

A total of 1,748 wildfires were included in the 2002 wildfire emission inventory with a mean duration for each fire of 3.3 days. These fires represented a total of 1,281,000 tons $PM_{2.5}$ and 1,490,000 tons $PM_{2.5}$ with smoldering factored in. An estimated total of approximately 5.3 million acres and 124 million tons of fuel were consumed by wildfire in 2002. Wildfire acres burned were highest during the summer months and peaked in the month of July. Wildfire activity differed widely by state with the highest activities in Alaska and Oregon.

A total of 35 Wildland Fire Use (WFU) events were included in the 2002 Phase II fire emission inventory. These fires lasted an average of 10.3 days, burned a total of 202,000 acres and emitted 82,000 tons of $PM_{2.5}$.

The 2002 prescribed fire emission inventory was comprised of significantly more events than the wildfire inventory with 16,396 original fire days. The total acreage consumed by prescribed burns was 649,000 acres and the total fuel consumed was approximately 7.2 million tons. Over 45 percent of the prescribed burning activity records were piled fuels. Temporally, prescribed burning had two peaks: one in the spring and a higher peak in the fall.

Non-federal prescribed rangeland burning contributed 1.04 million acres burned and 15,000 tons of $PM_{2.5}$ to the 2002 inventory while agricultural burning totaled 2.2 million burned acres and 35,000 tons $PM_{2.5}$. The lower emissions rates with respect to acres burned of both of these sources (relative to wildland burning) are indicative of lower average fuel loadings.

Wildfires contributed nearly 88 percent of the total emission of $PM_{2.5}$ for the 2002 Phase II EI. Prescribed burning and WFU fires contributed 4.2 percent and 4.8 percent, respectively. Rangeland and agricultural contributed 3 percent combined. Wildfire contributed the dominant percentage of $PM_{2.5}$ due to a combination of greater acres of activity and higher fuel loading rates.

According to the FEJF natural and anthropogenic categorization, 4 percent of the Phase II EI $PM_{2.5}$ emissions were classified as anthropogenic and 96 percent were classified as natural.

Table 36 and Figures 12 through 22 present the results of the Phase II EI. The assortment of figures, though not an exhaustive display for emission inventory statistics, is intended to provide a meaningful summary of the Phase II EI data.

Table 36: 2002 Phase II EI Fire Activity and $PM_{2.5}$ Emissions by State – All Fire Types

(Including fuel loading and $PM_{2.5}$ emissions added due to smoldering.)

	Wildfire				Prescribed Fire				WFU			
State	Fire Days	Acres	Tons Fuel Consumed	Tons $PM_{2.5}$	Fire Days	Acres	Tons Fuel Consumed	Tons $PM_{2.5}$	Fire Days	Acres	Tons Fuel Consumed	Tons $PM_{2.5}$
AK	1,109	1,790,533	66,614,205	802,701	214	1,108	15,024	177	158	159,554	5,611,305	67,616
AZ	402	556,601	8,375,651	100,927	1,412	103,619	1,814,906	20,230	0	0	0	0
CA	907	505,940	9,294,232	111,995	1,595	86,790	847,822	9,396	38	4,051	191,197	2,304
CO	446	412,633	8,998,546	108,432	186	17,425	56,988	379	52	22,852	676,518	8,152
ID	286	78,141	617,118	7,436	1,308	89,754	995,366	11,661	56	3,543	156,105	1,881
MT	220	113,463	921,178	11,100	2,815	77,719	666,265	7,086	4	25	1,180	14
ND	148	83,397	303,228	3,654	185	26,826	59,151	713	0	0	0	0
NM	244	247,243	1,649,118	19,872	155	25,292	185,821	2,029	16	4,759	16,141	194
NV	178	82,163	1,629,911	19,640	71	5,795	31,106	327	0	0	0	0
OR	835	899,800	19,342,371	233,076	4,174	129,068	1,713,780	12,553	0	0	0	0
SD	156	78,566	199,517	2,404	219	8,811	20,294	245	0	0	0	0
UT	436	210,711	2,521,795	30,388	385	14,531	190,945	2,021	14	545	16,285	196
WA	200	89,809	983,495	11,851	3,377	41,164	363,093	2,243	0	0	0	0
WY	268	127,486	2,191,658	26,409	349	21,140	234,928	2,360	31	6,220	95,208	1,147
Total	5,835	5,276,485	123,642,024	1,489,886	16,445	649,044	7,195,489	71,421	369	201,548	6,763,940	81,505

	Agricultural Burning				Non-Federal Rangeland Prescribed Burning			
State	Fire Days	Acres	Tons Fuel Consumed	Tons $PM_{2.5}$	Fire Days	Acres	Tons Fuel Consumed	Tons $PM_{2.5}$
AK	0	0	0	0	0	0	0	0
AZ	1,344	16,203	32,045	209	352	250,001	437,502	3,708
CA	62,428	727,641	1,734,750	8,543	383	40,000	70,000	593
CO	2,124	38,231	139,180	852	372	12,000	21,000	178
ID	11,155	292,352	604,994	4,303	234	8,000	14,000	119
MT	1,848	8,888	24,796	194	556	150,001	262,502	2,225
ND	17,627	212,574	414,306	2,162	327	25,000	43,750	371
NM	329	21,180	35,745	190	311	60,000	105,000	890
NV	0	0	0	0	102	1,000	1,750	15
OR	2,250	129,781	436,622	3,407	450	300,001	525,002	4,449
SD	528	5,018	15,998	136	590	150,001	262,501	2,225
UT	725	16,684	36,605	210	196	25,000	43,750	371
WA	3,127	656,705	2,515,880	13,797	114	6,000	10,500	89
WY	2,506	38,221	70,871	576	141	15,000	26,250	222
Total	105,991	2,163,478	6,061,792	34,578	4,128	1,042,003	1,823,508	15,454

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Figure 12: Annual Acres Burned by Fire Type

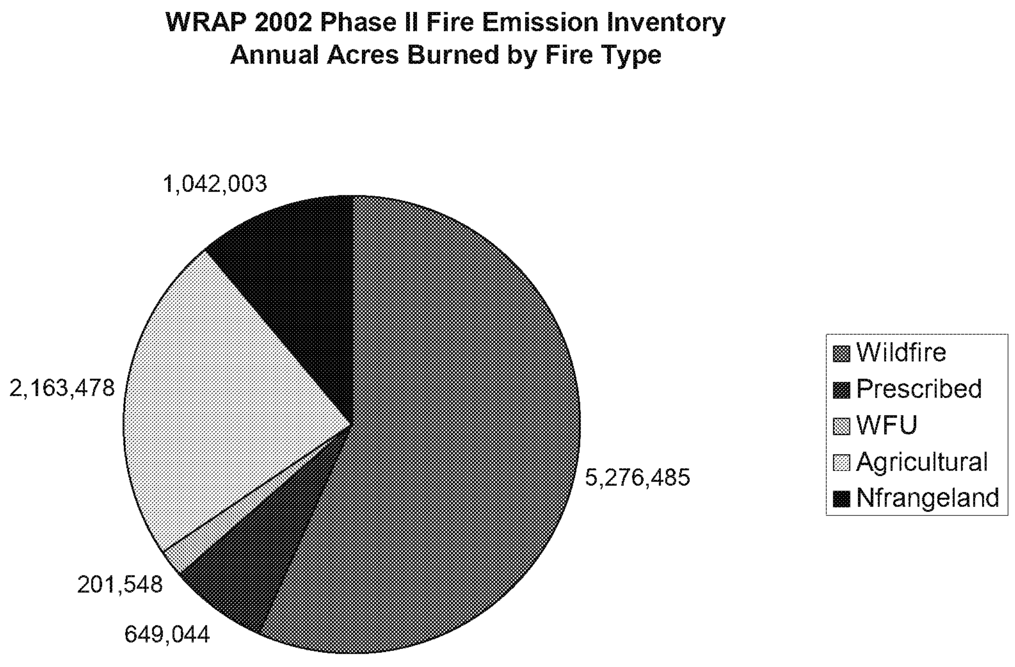


Figure 13: Annual $PM_{2.5}$ Emissions by Fire Type (tons)

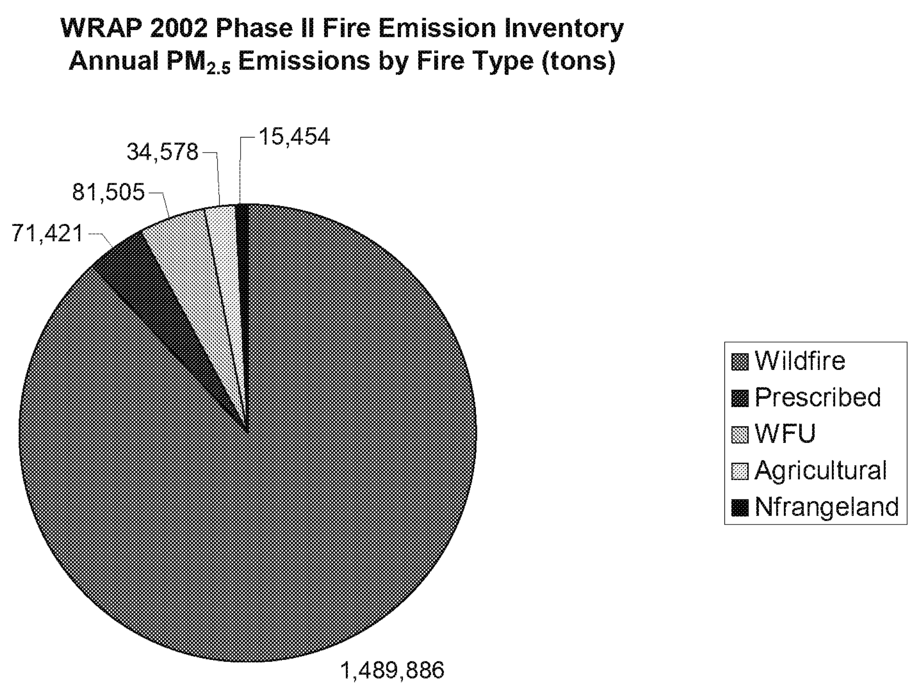
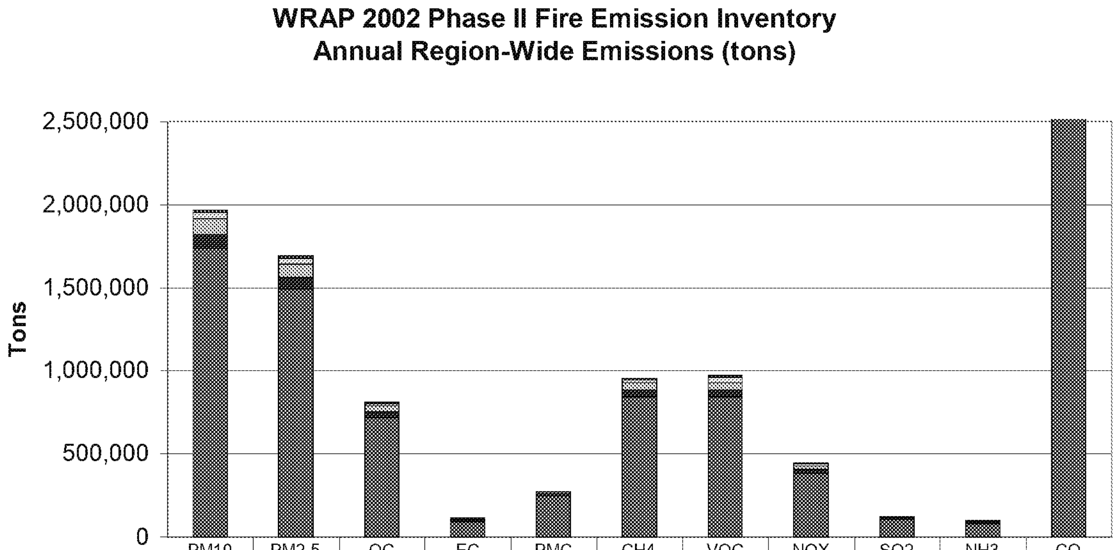


Figure 14: Annual Region-Wide Emissions (tons)



	PM10	PM2.5	OC	EC	PMC	CH4	VOC	NOX	SO2	NH3	CO
Nfrangeland	16,165	15,454	6,948	4,039	711	8,215	10,877	4,577	611	2,316	115,875
Agricultural	36,587	34,578	14,329	6,747	1,745	13,939	32,575	15,710	2,374	7,363	364,202
WFU	95,033	81,505	39,231	5,073	13,528	45,995	45,995	20,968	5,749	4,397	977,389
Prescribed	82,014	71,421	34,803	4,542	10,593	43,328	41,999	22,306	6,116	3,918	835,917
Wildfire	1,737,170	1,489,886	717,124	92,732	247,284	840,766	840,766	383,290	105,096	80,367	17,866,27

Wildfire Prescribed WFU Agricultural Nfrangeland

Figure 15: State Totals for All Fire Sources as a Percentage of Regional Total (Annual)

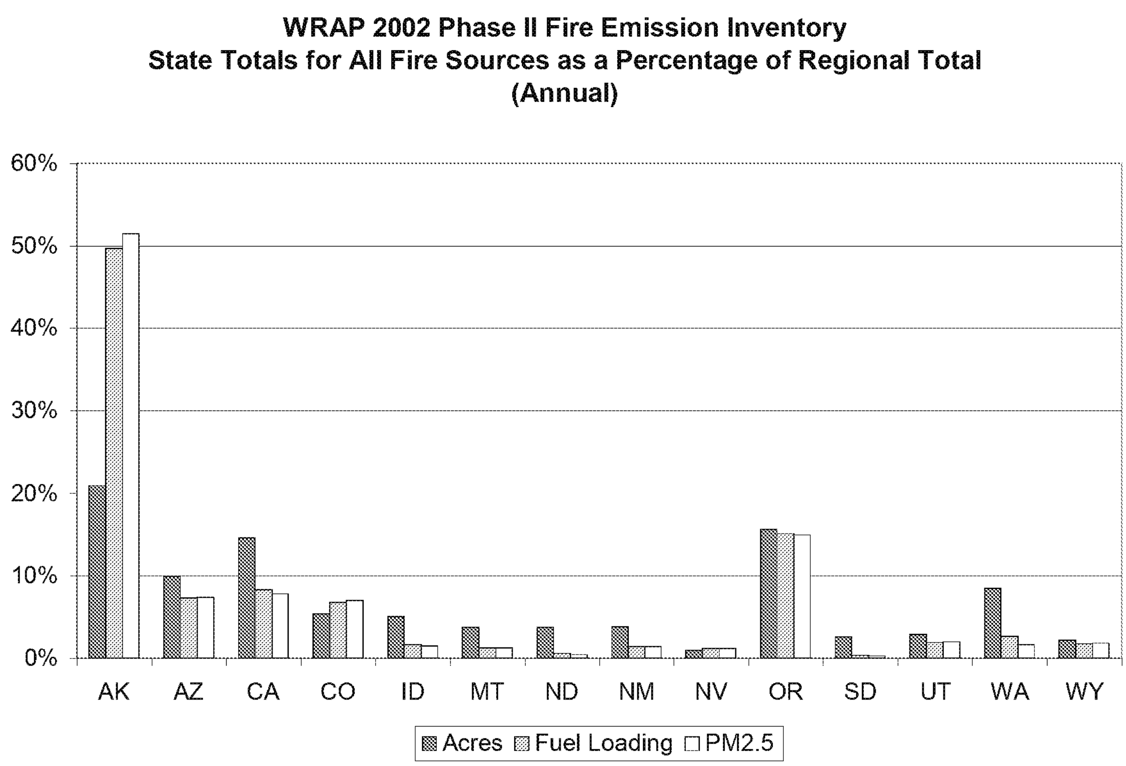


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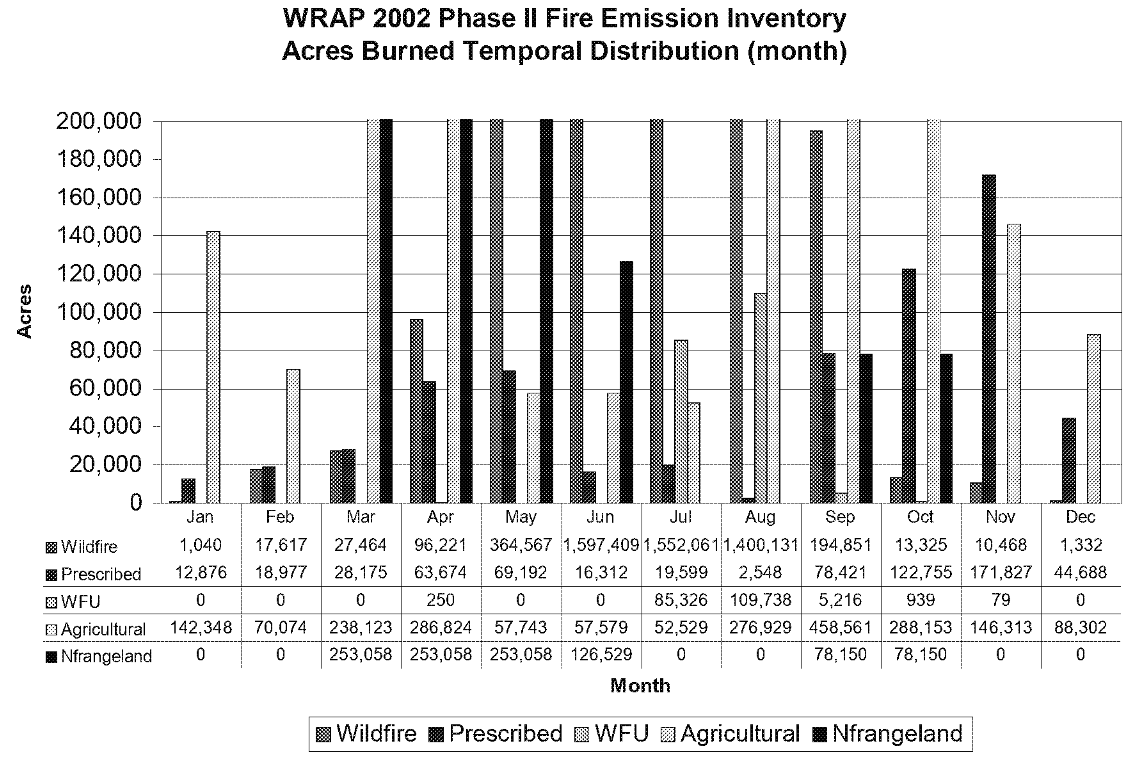
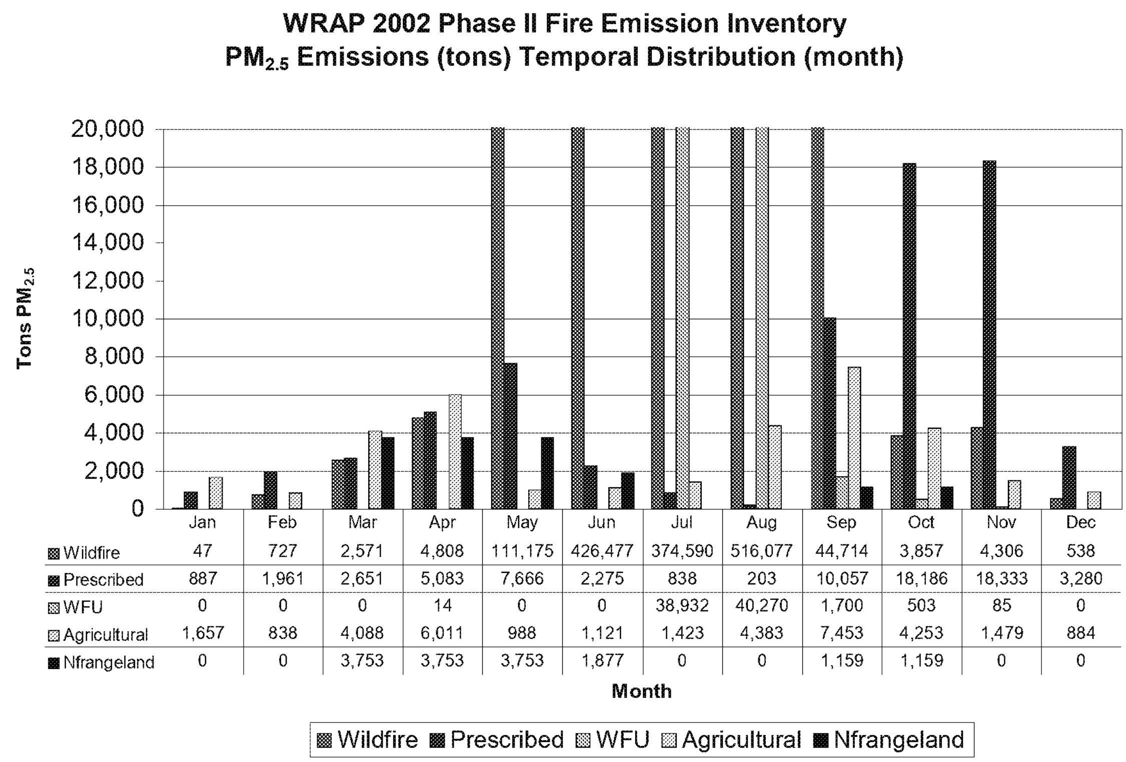
Figure 16: Acres Burned Temporal Distribution (month)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wildfire	1,040	17,617	27,464	96,221	364,567	1,597,409	1,552,061	1,400,131	194,851	13,325	10,468	1,332
Prescribed	12,876	18,977	28,175	63,674	69,192	16,312	19,599	2,548	78,421	122,755	171,827	44,688
WFU	0	0	0	250	0	0	85,326	109,738	5,216	939	79	0
Agricultural	142,348	70,074	238,123	286,824	57,743	57,579	52,529	276,929	458,561	288,153	146,313	88,302
Nfrangeland	0	0	253,058	253,058	253,058	126,529	0	0	78,150	78,150	0	0

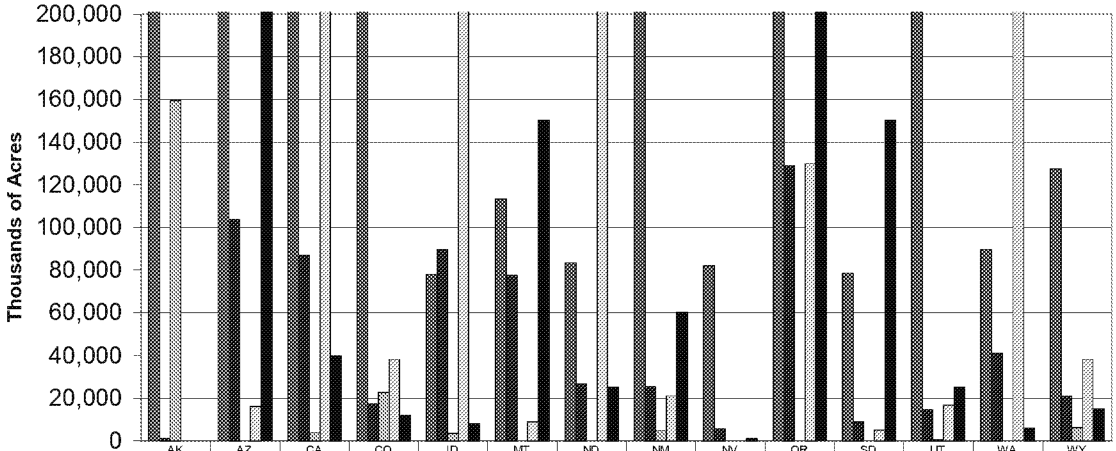
Figure 17: $PM_{2.5}$ Emissions (tons) Temporal Distribution (month)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wildfire	47	727	2,571	4,808	111,175	426,477	374,590	516,077	44,714	3,857	4,306	538
Prescribed	887	1,961	2,651	5,083	7,666	2,275	838	203	10,057	18,186	18,333	3,280
WFU	0	0	0	14	0	0	38,932	40,270	1,700	503	85	0
Agricultural	1,657	838	4,088	6,011	988	1,121	1,423	4,383	7,453	4,253	1,479	884
Nfrangeland	0	0	3,753	3,753	3,753	1,877	0	0	1,159	1,159	0	0

Figure 18: Annual Acres Burned Spatial Distribution (state)

WRAP 2002 Phase II Fire Emission Inventory
Annual Acres Burned Spatial Distribution (state)



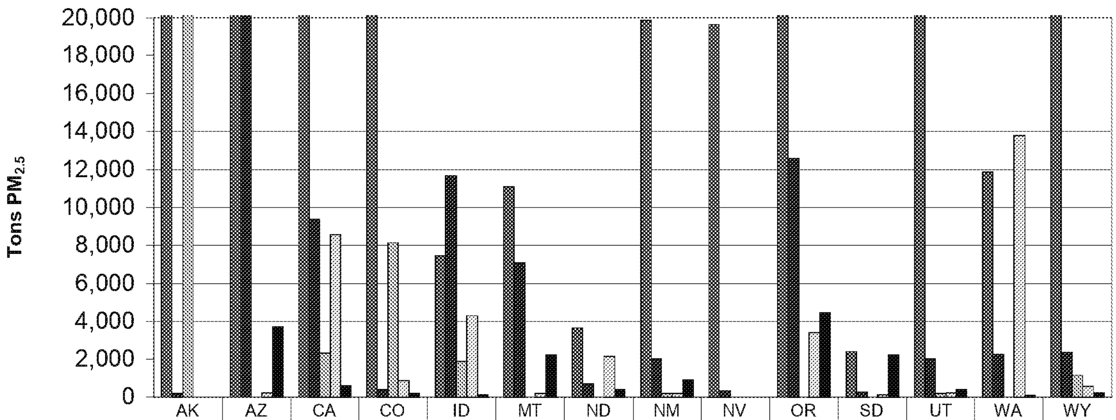
	AK	AZ	CA	CO	ID	MT	ND	NM	NV	OR	SD	UT	WA	WY
Wildfire	1,790,533	556,601	505,940	412,633	78,141	113,463	83,397	247,243	82,163	899,800	78,566	210,711	89,809	127,486
Prescribed	1,108	103,619	86,790	17,425	89,754	77,719	26,826	25,292	5,795	129,068	8,811	14,531	41,164	21,140
WFU	159,554	0	4,051	22,852	3,543	25	0	4,759	0	0	0	545	0	6,220
Agricultural	0	16,203	727,641	38,231	292,352	8,888	212,574	21,180	0	129,781	5,018	16,684	656,705	38,221
Nfrangeland	0	250,001	40,000	12,000	8,000	150,001	25,000	60,000	1,000	300,001	150,001	25,000	6,000	15,000

State

Wildfire Prescribed WFU Agricultural Nfrangeland

Figure 19: Annual $PM_{2.5}$ Emissions (tons) Spatial Distribution (state)

WRAP 2002 Phase II Fire Emission Inventory
Annual $PM_{2.5}$ Emissions (tons) Spatial Distribution (state)



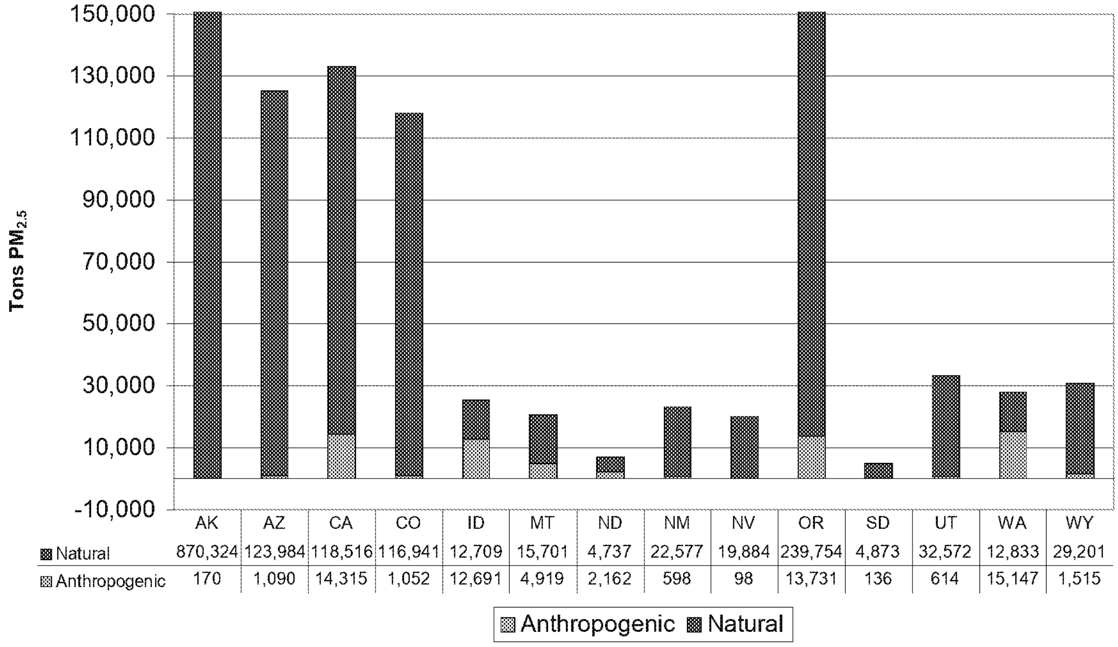
	AK	AZ	CA	CO	ID	MT	ND	NM	NV	OR	SD	UT	WA	WY
Wildfire	802,701	100,927	111,995	108,432	7,436	11,100	3,654	19,872	19,640	233,076	2,404	30,388	11,851	26,409
Prescribed	177	20,230	9,396	379	11,661	7,086	713	2,029	327	12,553	245	2,021	2,243	2,360
WFU	67,616	0	2,304	8,152	1,881	14	0	194	0	0	0	196	0	1,147
Agricultural	0	209	8,543	852	4,303	194	2,162	190	0	3,407	136	210	13,797	576
Nfrangeland	0	3,708	593	178	119	2,225	371	890	15	4,449	2,225	371	89	222

State

Wildfire Prescribed WFU Agricultural Nfrangeland

Figure 20: Annual Natural and Anthropogenic $PM_{2.5}$ Emissions by State (tons)

WRAP 2002 Phase II Fire Emission Inventory
Annual Natural and Anthropogenic $PM_{2.5}$ Emissions by State (tons)



	AK	AZ	CA	CO	ID	MT	ND	NM	NV	OR	SD	UT	WA	WY
Natural	870,324	123,984	118,516	116,941	12,709	15,701	4,737	22,577	19,884	239,754	4,873	32,572	12,833	29,201
Anthropogenic	170	1,090	14,315	1,052	12,691	4,919	2,162	598	98	13,731	136	614	15,147	1,515

Figure 21: Annual Anthropogenic $PM_{2.5}$ Emissions by State and Fire Type (tons)

WRAP 2002 Phase II Fire Emission Inventory
Annual Anthropogenic $PM_{2.5}$ Emissions by State and Fire Type (tons)

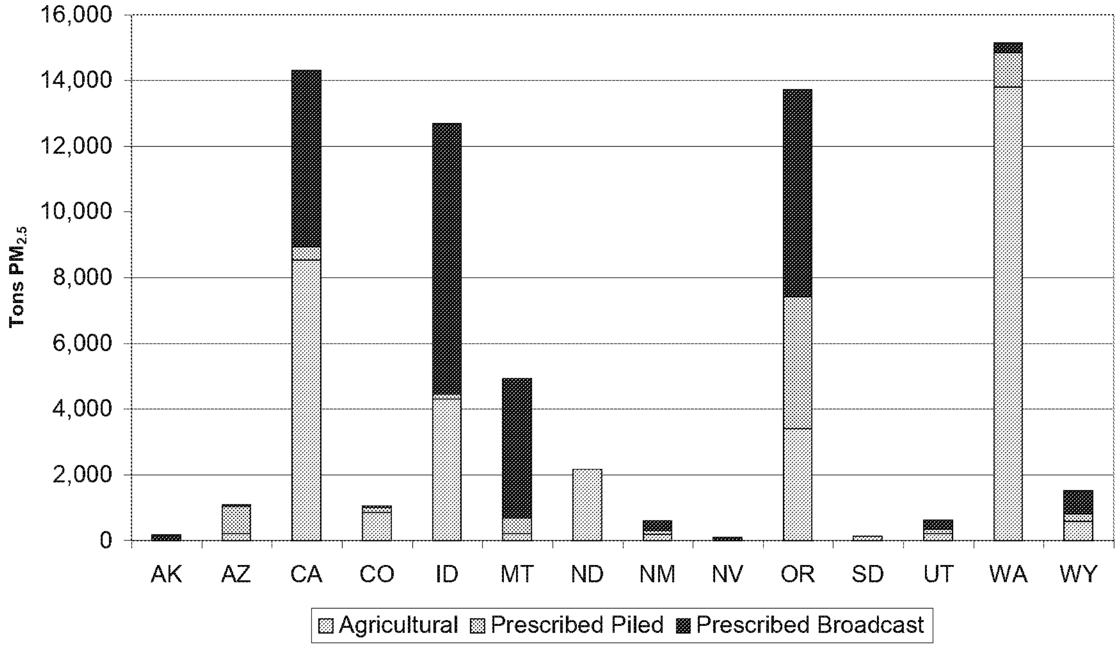


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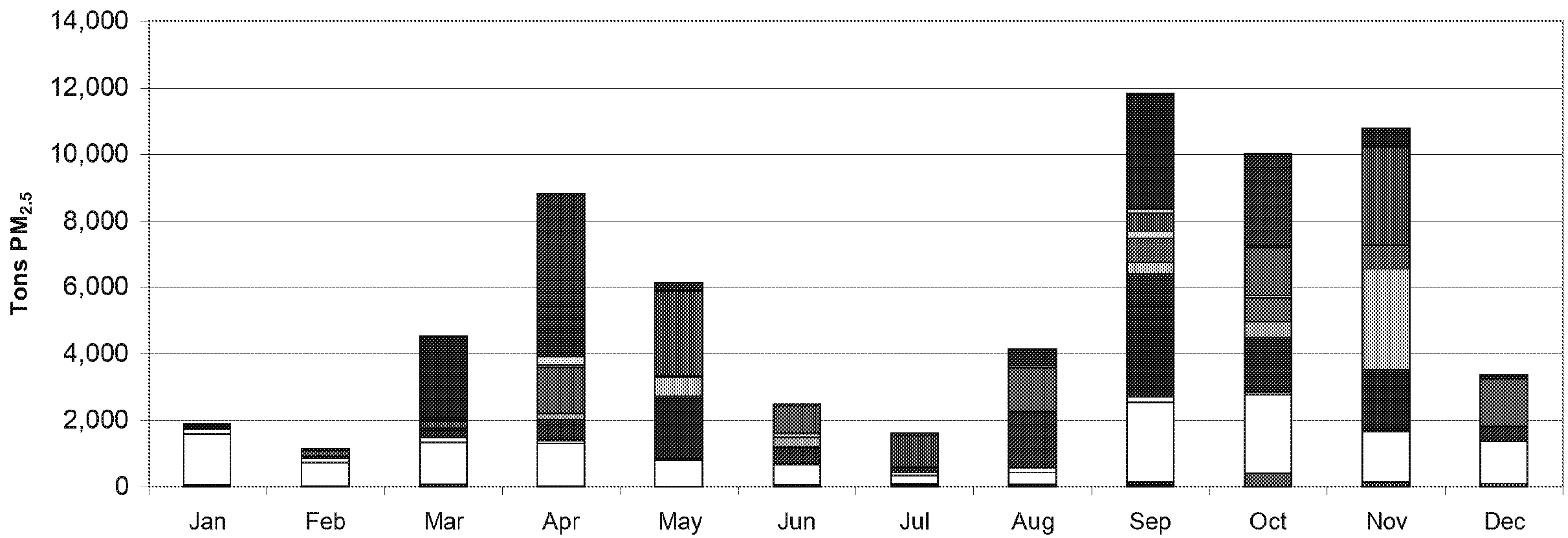
Figure 22: Anthropogenic $PM_{2.5}$ Emissions by Month and State (tons)

WRAP 2002 Phase II Fire Emission Inventory
Anthropogenic $PM_{2.5}$ Emissions by Month and State (tons)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
WA	30	38	2,472	4,874	212	38	76	490	3,457	2,767	557	137
UT	7	11	14	270	22	17	0	88	116	58	8	2
SD	0	0	68	68	0	0	0	0	0	0	0	0
OR	43	156	188	1,377	2,553	814	941	1,293	563	1,450	2,946	1,407
NV	24	0	10	1	56	0	0	0	0	2	5	0
NM	56	68	50	11	0	141	20	3	184	62	2	1
ND	0	0	0	0	0	0	0	0	720	721	721	0
MT	0	0	18	184	563	270	4	14	371	464	3,030	0
ID	0	0	221	644	1,872	539	135	1,673	3,704	1,646	1,787	470
CO	152	132	143	66	22	6	120	137	137	67	65	5
CA	1,528	694	1,248	1,298	827	604	221	371	2,395	2,365	1,519	1,245
AZ	55	38	90	17	0	40	53	16	109	416	149	107
AK	0	0	0	0	0	18	50	53	49	0	0	0

AK AZ CA CO ID MT ND NM NV OR SD UT WA

SECTION 6

DELIVERABLES AND END USER DATA SUPPORT

Deliverables for this contract were made available on CD-ROM and for download on the Internet. The link(s) to the webpage for deliverables are on the WRAP's website at http://www.wrapair.org/forums/fejf/tasks/FEJFtask7.html. Digital products include:

- SMOKE input text files (IDA format) for all fire sources. These are PTINV, PTDAY, and PTHOUR files as specified by the WRAP Modeling Forum and Regional Modeling Center.

- NIF 3.0 for Fire (NIF Point text format) for all fire sources intended for CERR submittal and upload to the WRAP EDMS. These files were provided in a region-wide file and by state for each fire source.

- This final report as a PDF file.

The initial delivery of the electronic data files of fire inventories were acquired by the WRAP's contractors for the Emissions Data Management System (EDMS) and the Regional Modeling Center (RMC). These "end users" of the Phase II emissions inventory files identified several data content and format issues as the electronic files were integrated into the EDMS or the modeling system. As data issues were discovered, the contractors (Pechan and the RMC) contacted Air Sciences to investigate the cause of the data problems. Some of these issues stemmed from the formats of the files delivered by data suppliers (e.g., states) during the QC Binder review process (labeled DATA SUPPLIER in the list below). Other issues (labeled as END USER tasks) reflect specific data formatting demands or recommendations from the RMC or Pechan. The DATA SUPPLIER and END USER tasks were completed to resolve issues in the emission inventory data that would not have been reasonably discovered by Air Sciences until end users of the data attempted to utilize the data files.

In addition, during the QC effort involving the end users, Air Sciences discovered several issues that could have reasonably been discovered by Air Sciences during our internal QC checks of the data. These tasks have been labeled AIR SCIENCES and there are no costs to the FEJF associated with executing these tasks.

1. Malformed dates in CA Ag files (DATA SUPPLIER).

   Issue: Records were intended to be dropped and had zero emissions.

   Resolution: Drop flag enforced in the emissions processing file.

2. Blank dates in AZ prescribed burning (DATA SUPPLIER).

Issue: Error in date parsing during raw data import.

Resolution: Corrected records and re-merged to main database.

3. NIF files inconsistently referred to year "2002" vs. "02" (DATA SUPPLIER).

   Issue: Format of year data was variable across data coming into system from federal and state data sources. PT files required "02" and NIF/EDMS system required "2002."

   Resolution: Revised NIF export script to enforce "2002." PT export script continued to enforce "02."

4. Missing PTHOUR records with regard to PTINV file (AIR SCIENCES).

   Issue: CA agricultural burning data records were missed during data processing for a block of records during the integration of CA records during the QC-binder review/integration process.

   Resolution: Batch file amended.

5. NIF export produced large Combustion Efficiency (CE) table (END USER).

   Issue: The CE table was included in the NIF scripts, and the NIF export files were checked for completeness (specifically, valid values for fields for control efficiency were filled in so that NIF files would pass EPA's QA Checker). Advised by Pechan to flag events as "uncontrolled" in EM table and thereby eliminating the need for CE table.

   Resolution: Amended NIF script. EPA QA checker run with blank text file for CE table as work around.

6. SCC miscode.

   Issue: SCC miscoded for certain piled prescribed burns (note: Natural/Anthropogenic flagging was correct) (AIR SCIENCES).

   Resolution: Corrected SCC formula in Excel and recalculated emission inventory worksheet.

7. Emission factor for "other ag burning" in incorrect units (in the look-up table as kg/Mg but should be lbs/ton, a factor of 2x greater than kg/Mg) (AIR SCIENCES).

   Issue: Problem was isolated to that crop code (which is used exclusively when crop type information is not provided in source data). Correction added about 250 tons $PM_{2.5}$ to the inventory, mostly in CA with small amounts in two other states.

   Resolution: Corrected look-up table and recalculated emission inventory worksheet.

SECTION 7

REFERENCES

Air Sciences Inc. 2002. Integrated Assessment Update and 2018 Emission Inventory for Prescribed Fire, Wildfire, and Agricultural Burning. Draft Report. Prepared for the Fire Emissions Joint Forum of the Western Regional Air Partnership.

Anderson, G. K., D. V. Sandberg and R. A. Norheim. 2001. Fire Emission Production Simulator (FEPS) User's Guide. Version 1.0. USDA Forest Service.

Battye, W., and R. Battye. 2001. Development of Emissions Inventory Methods for Wildland Fire. Draft Final Report to the U.S. EPA OAQPS.

Cohen, J.D. and J.E. Deeming. 1985. The National Fire-Danger Rating System: Basic Equations. USDA, Forest Service. Report PSW-82.

Eastern Research Group, Inc.; Enviro-Tech Communications. 2002. Non-Burning Management Alternatives on Agricultural Lands in the Western United States. Prepared for the Fire Emissions Joint Forum of the Western Regional Air Partnership.

U.S. Environmental Protection Agency. 1996. Supplements to the Compilation of Air Pollutant Emission Factors AP-42, Fifth Edition, Volume I: Stationary Point and Area Sources, Section 13.1- Wildfires and Prescribed Burning.

APPENDIX A

Data Gathering and Compilation

Wildfire

Wildfire activity data was collected from federal databases by WRAP staff.

- Contact name and agency: John Graves, Arizona DEQ.
- Date received: 7/24/2003
- Assumptions: Wildfire activity data reportedly included both wildfire and wildland fire use (WFU). Therefore, WFU activity in prescribed fire databases not included in the (prescribed) fire activity. This was a categorical decision based on information provided by John Graves that was subsequently applied to all states. Decision was made since some databases for prescribed fire activity also included WFU activity, for example, the DOI database (see below).

Prescribed Fire

Alaska

- Contact name and agency: Ron King, Program Manager, Alaska DEC. (Backup contact: Joan Hardesty, Alaska DEC.)
- Date received: 4/20/04
- Assumptions: None
- Additional notes: Data only contained wildfire records. Based on further inquiry prescribed fire activity for AK not available. However, a NFDRS fuel loading map for AK was located in the process of additional research on AK fire data (downloadable from the state forest health web site). This map was incorporated into the wildfire inventory in order to assign fuel loading to the AK wildfire records that did not have an NFDRS entry. The AK map was based on the Canadian equivalent of the NFDRS, the CFFDRS. A cross-referenced key to convert the CFFDRS codes to NFDRS codes was obtained from the same source as the map (http://agdc.usgs.gov/AGDCgateway.html).

Arizona

- Contact name and agency: Mark Fitch, Arizona DEQ.
- Date received: 3/8/04
- Assumptions: End date assumed to be same as start date, effectively creating all one-day fire events. Both burn types in the database, specifically, "Activity-nonpile" and "Natural" were assumed to be prescribed burns, broadcast burns.
- Additional notes: Complete data set with approximately 73,000 acres, distributed over 433 fire entries, and several burn agencies.

California

- Contact name and agency: Neva Sotolongo, California ARB
- Date received: 4/8/04
- Assumptions: Burn type assumed to be all broadcast burns. No identifier for piles included in data. Some records have fire end date of ZERO. End date assumed to be same as start date, effectively creating one-day fire events.
- Additional notes: The data only included incomplete records reported by CDF, not from other agencies. Hence, the data underestimated actual statewide activity. Data was received in the form of a GIS layer, which was converted to latitude/longitude by Air Sciences Inc.

Colorado

- Contact name and agency: Colleen Campbell, Colorado DPHE
- Date received: 4/9/04
- Assumptions: End date assumed to be same as start date, effectively creating one-day fire events. Fuel loading – broadcast data was provided in terms of fuel loading and consumption (by size class). Pile loading only indicated volume of piles, percent of piles and corresponding PM emissions, not actual tonnage. Tonnage was back-calculated from PM emissions in one of two ways: (1) if pile volume and consumption available, then calculated by multiplication (Pile volume)*(percent consumption)*(loading per pile volume). The latter was back-calculated from PM emissions assuming the same emission factors for pile as for broadcast burns. (2) if only acres available for pile burn, assumed (geometric) mean of all CO pile burns (9.1 t/a). Also, the approach described under (1) resulted in two entries with very high fuel loading (up to >920 t/a); these two records were adjusted by assuming the geometric mean pile loading (~10 t/a). This adjustment decreased fuel loading and increased the acreage, thereby keeping the total fuel consumed the same as the original data.
- Additional notes: This data set had ~18K acres distributed over 189 fire records. Data was received in two different file formats, which were combined to provide the most complete information. The daily acres file was used to derive actual acres burned under each permit. The general permit information was used as a look-up table to fill out the activity data in the daily acres file, for example, fire location.

Idaho

- Contact name and agency: David Grace, USFS.
- Date received: 3/22/04
- Assumptions: Data missing description of fire type. All fires assumed to be broadcast burns.
- Additional notes: Although data was provided by the USFS, the data was originally assembled by ID-DEQ (e-mail communication, David Grace, 3/22/04). After deletion of nine fire records dated in 2003, this data set was ~33K acres, distributed over 554 fire entries, and several burn agencies.

Montana

- Contact name and agency: Robert Habeck, Montana DEQ.
- Date received: 3/12/04
- Assumptions: None.
- Additional notes: Complete data set with ~219K acres, distributed over 1,813 fire entries, and several burn agencies.

North Dakota

- Contact name and agency: Chuck McDonald, North Dakota Dept. of Health.
- Date received: 4/1/04
- Assumptions: If more than one section entered for location, set to first section only.
- Additional notes: Data received as hard copy and entered into spreadsheet. Corrected mix-up in units of the pre-burn fuel loading in the data entry sheets.

New Mexico

- Contact name and agency: Lisa Bye, New Mexico DEQ.
- Date received: 3/16/04
- Assumptions: End date assumed to be same as start date, effectively creating one-day fire events. If more than one section entered for location, set to first section only, but this was not a major issue, since latitude and longitude were provided for each entry as well.
- Additional notes: Complete data set with ~9K acres, distributed over 44 fire entries, and several burn agencies. Also, two entries in the data set (~3,500 acre total) had 2003 data instead of 2002. Assumed to be 2002.

Nevada

- Contact name and agency: Samuel Jackson, Nevada DEP.
- Date received: 4/13/04
- Assumptions: Fuel loading provided for 3 records only; loading for remaining records based on NFDRS. NFDRS assigned by the fuel type description provided in the raw data. Location - some fire locations were reported as a lat/long combination; most reported as TRS. If more than one section entered for location, set to first section only.
- Additional notes: Data received in form of Excel file with 21 fire records, totaling ~8K acres.

Oregon

- Contact name and agency: Mike Ziolko, Oregon DF.
- Date received: 4/19/04
- Assumptions: The piled burns were inconsistent in quality. Some records had very high acreages associated, up to 9,600 acres, others had very high fuel loading, up to 2,500 tons/acre. In order to resolve these unrealistically high values, the mean loading for piled burns in the OR data (excluding the outliers, specifically, acreage>1,500 acres or loading >150 t/a) was calculated. Next all OR pile burns were normalized based on the (geometric) mean loading, specifically, 12.5 t/a. Since this procedure concurrently adjusted fuel loading and acreage, the total fuel consumption for each fire record stayed the same. Location – format of state TRS notation was converted to GIS format. Specifically, T or R entries, which were in the hundreds, had the last zero removed (for example, township 360 N changed to 36N).
- Additional notes: This data set was clean and complete except for inconsistent reporting of piled fire acreage, with ~166K acres total, distributed over 3,603 fire records.

South Dakota

- Contact name and agency: Steven Hasenohrl, South Dakota DA.
- Date received: 3/26/04
- Assumptions: No fire type provided, so assumed to be broadcast burn.
- Additional notes: Only one state record for 2002 (150 acres).

Utah

- Contact name and agency: Greg Zschaechner, Utah DEQ. (Via Pete Lahm)
- Date received: 2/20/04
- Assumptions: None
- Additional notes: Only 11 records totaling ~1.5K acres satisfied data quality objectives and were carried over to EI. UTM coordinates (provided) were converted to latitude and longitude using a GIS overlay map.

Washington

- Contact name and agency: Mark Gray, Washington DNR.
- Date received: 4/6/04
- Assumptions: Agency information based on key from Mark Gray. Burn type indicated as piled or broadcast. Calculated default fuel loadings were 14.2 and 8.5 t/a for broadcast- and piled burns, respectively. Broadcast fuel loading- if data available loading in t/a calculated from provided data, if not, set to default. Piled fuel loading set to default loading, calculated as the mean loading for broadcast burns, multiplied with fuel collection efficiency of 60 percent (*0.6). Blackened acres for broadcast burns were available from the data. Acres for piled burns (not provided) were calculated based on total loading (provided) and default tonnage per acre. Location – format of state TRS notation was converted to GIS format. Specifically, T or R entries, which were in the hundreds, had the last zero removed (for example, township 360 N changed to 36N).
- Additional notes: Large data set containing 3,261 records totaling ~41K acres.

Wyoming

- Contact name and agency: Darla Potter, Wyoming DEQ.
- Date received: 8/3/04
- Assumptions: Start date - assumed to be same as date in comment field. If comment data absent, set to planned date; if planned date absent, then assumed to be on submitted date. End date - assumed to be same as start date, effectively creating one-day fire events. Fuel type - raw data gives fuel type. This description was specific enough to assign an NFDRS fuel model (letter code). Fire location - if more than one section reported for location, set to first section only. Fire type - several fire entries without acres, but with number of piles. In absence of loading data, the median pile size was calculated from all complete WY acres by number of pile combinations. This resulted in 1 acre per pile (n=24). For all pile burns without acreage then, acreage was

set to 1 acre per pile. Fuel loading – no data, but will be calculated based on assigned NFDRS model.

- Additional notes: The pre-processing described above resulted in ~40K acres, distributed over 100 fire entries, and several burn agencies. One 11,000 fire entry was deleted from database upon recommendation as it never was burned (personal communication, Gavin Lowell, 6/3/04).

DOI-1202

- Contact name and agency: [Confirm with source]
- Date received: [Confirm with source]
- Assumptions: All fires assumed to be broadcast burns. Location based on provided latitude and longitude or, alternatively, TRS coordinates. Fuel loading based on NFDRS fuels map, which was either provided in the data or derived from a GIS overlay with the NFDRS fuels map.
- Additional notes: This data set covered four agencies: BIA, BLM, FWS and NPS. It was clean and had ~180K acres, distributed over 707 fire records, all for Rx on USFS lands.

NIFPORS

- Contact name and agency: Susan Lee, USFS
- Date received: 4/20/04
- Assumptions: Fuel loading was not provided and was calculated based on NFDRS fuel loading map. Two large fires set to zero due to extreme outliers: UT Dixie National Forest D3 Adams Head (~25K acres) and D3 Sandford Creek (~10K acres). Both were broadcast burns. If kept in database, these fires would have been assigned to one-day event only.
- Additional notes: This data set was clean and had ~290K acres, distributed over 1,145 fire records, all for Rx on USFS lands.

FASTRAC (WA and OR)

- Contact name and agency: Jim Russell, USFS.
- Date received: 4/22/04
- Assumptions: None
  - Additional notes: This data set was similar to data provided earlier by the state agencies in WA and OR. Hence, to avoid duplicate fire entries this data was not

incorporated in the emission inventory. However, it was used in the quality assurance effort of the WA and OR state data.

Agricultural Burning – QC Packet Responses

Alaska

- No Packet sent to Alaska

Arizona

- Contact name and agency: Randy Sedlacek/Trevor Baggiore, USFS c/o Arizona DEQ
- QC response: No change.

California

- Contact name and agency: Neva Sotolongo, CA EPA
- QC response: All new data - Year 2000 statewide database. 2002 database for San Joaquin Valley Air District.
- Additional notes: The 2000 CA statewide database included 71,457 event records. All records in the statewide database included a crop and county, most included date or month, some included TRS location.
- The 2002 SJV ag burning activity database included 51,782 event records. All records included county, crop, and date. The database included location data in the form of street addresses rather than coordinates or TRS data. Reportedly, TRS location data is available, but it was never received.
- For the WRAP inventory, the statewide database was used but the records for SJV and all of Kern County were replaced with the SJV 2002 data. The inventory includes 9,324 records from the statewide database and 51,712 records from the SJV database. A few of these records were subsequently dropped because of incomplete information.

Colorado

- Contact name and agency: Coleen Campbell, CO APCD
- QC response: Initial response was from James Sharkoff, who reported that no ag burning occurs in CO. Further inquiry led to an ag burning summary from Coleen Campbell. The data submitted by Coleen was an annual summary with three crop types by county.

- Additional notes: A monthly distribution of crop burning based on local anecdotal information, developed in coordination with Coleen, was used for temporal allocation.

Idaho

- Contact name and agency: Diane Riley, ID DEQ
- QC response: New data for 16 counties including 1,088 records. Suggested updating 1996 NASS-based data with 2002 NASS data.
- Additional notes: Post-QC Phase II database for ID comes from three sources: new database for 16 counties from Diane Riley, NASS-based data for wheat and barley updated using 2002 NASS data, and 1996 EI data for remainder of counties and crops.

Montana

- Contact name and agency: James Carlin, MT DEQ
- QC response: MT submitted ditch burning data to supplement the existing ag burning activity data. The data included acres of ditch burning by month and county.
- Additional notes: MT ag burning inventory remained unchanged aside from the addition of ditch burning data.

New Mexico

- Contact name and agency: Rita Trujillo, NM Environmental Dept.
- QC response: NM submitted revised data, which included acres by county, month and crop.
- Additional notes: Rita Trujillo sent an electronic copy of Feedback Form B marked up with changes for the Phase II EI. The new data includes 20 records and replaces the 1996 EI data for NM.

Nevada

- Contact name and agency: Chester Sergent, NV Bureau of Air Quality
- QC response: No new data.
- Additional notes: 1996 EI had no data for NV ag burning. Existing 1996 data for NV was an annual summary of burning with no crop data. A special packet was sent to NV to solicit more specific data with crops and monthly allocation of burning. The response from NV was that there was no ag burning data available

other than the annual summary without crop information. This database does not meet the minimum requirements for the WRAP EI and cannot be included in the inventory without additional information concerning crops and temporal allocation.

North Dakota

- Contact name and agency: Gene Nelson, ND Health Dept.
- QC response: ND said the data looks representative for ND, and no changes were necessary.

Oregon

- Contact name and agency: Jeffrey Stocum, OR DEQ
- QC response: New database for 2002: annual summary of acres burned by crop plus a temporal allocation scheme to allocate the annual data to months.

South Dakota

- Contact name and agency: Rick Boddicker
- QC response: 5,000 ditch burning acres to replace SD ag burning data.
- Additional notes: Rick Boddicker reports that there is very little ag burning in South Dakota. Total burning is reported to be 1,000 to 5,000 acres to clear weeds and cattails in wet areas in eastern SD. For Phase II, 5,000 acres of ditch burning was estimated for SD and allocated equally between the counties on the eastern border. The temporal allocation was not changed from 1996 EI: half in March, half in April.

Utah

- Contact name and agency: Aaron Chambers, UT DEQ
- QC response: Annual summary of burning by crop and county to replace 1996 EI data.
- Additional notes: Aaron Chambers submitted 30 MS Excel files, each containing an annual summary of ag burning for 2002 for one county. Aaron sent some basic guidelines for when burning occurred, but said it was crop-specific and was unable to give a detailed temporal allocation by crop. A temporal allocation was derived using the guidelines given by Aaron and looking at Idaho and other WRAP data for each crop.

Washington

- Contact name and agency: Karen Wood, WA Ecology
- QC response: 2003 statewide ag burning database.
- Additional notes: Washington sent a new 2003 ag burning database to be used as the most representative data for 2002. The 2003 data was event-level data with TRS location, crop, month, and acres and residue loading. There are 3,235 records in the data set. This data replaced the Washington data in the 1996 EI.

Wyoming

- Contact name and agency: Darla Potter, WY DEQ
- QC response: New 2002 statewide ag burning inventory
- Additional notes: The new WY database for 2002 ag burning included acres by summary by county, crop, and month.

Nez Perce, Coeur d'Alene and Spirit Lake Tribes

- Contact name and agency: Alene George, Coeur d'Alene Lands Dept.
  Julie Simpson, Nez Perce Air Quality
  Frank Black Cloud, Spirit Lake Air Programs
- QC response: No formal response

APPENDIX B

WRAP NIF 3.0 for Fire Format Specification

Table B-1: WRAP NIF 3.0 for Fire - Transmittal Record

EPA NIF Field	WRAP NIF Fire Field	Example Value	Comment
strRecordType	Record Type	TR	TR for every record
strStateCountyFIPS	FIPS	02050	No two entries in this record will have the same FIPS code
strOrganizationName	Org Name	WRAP	
strTransactionType	Transaction Type	00	"00" means "Original"
intInventoryYear	Inventory Year	2002	
strInventoryTypeCode	Inventory Type	CRIT	"CRIT" = Criteria
lngTransactionCreationDate	Transaction Creation Date	20050204	Date of report generation
intIncrementalSubmissionNumber	Incremental Submission Number	1	All records get a submission number of 1 unless data gets submitted for a county more than once
sngReliabilityIndicator	(Blank)		
strTransactionComments	Comments on Inventory	no comment	Any comments on inventory. Can be entered when creating record
strContactPersonName	Client Name	Tom Moore	WRAP Contact name
strContactPhoneNumber	Client Phone Number	(970) 491-8837	WRAP Contact phone number
strTelephoneNumberTypeName	Client Phone Type	Office	WRAP Contact phone number type
strElectronicAddressText	Client E Address	mooret@cira.colostate.edu	WRAP Contact E address
strElectronicAddressTypeName	Type of E Address	Email	WRAP Contact E address type
strSourceType	Source Type	FIRE	FIRE is not a valid NIF code. Submitted as such to make implicit that this is a new format
strAffiliationType	Affiliation Type	Report Certifier	According to NIF doc. is always Report Certifier
sngFormatVersion	NIF Format version	3	NIF version 3.0
strTribalCode	Tribal Code	000	WRAP does not report tribal code but required data field in NIF format "000" = "not used"

Table B-2: WRAP NIF 3.0 for Fire - Site Record

EPA NIF Field	WRAP NIF Fire Field	Example Value	Comment
strRecordType	Record Type	SI	SI for every record
strStateCountyFIPs	FIPS	02110	
strStateFacilityIdentifier	Fire ID	AK-WF-229-1	Fire ID must be unique for every flaming fire day. Every corresponding smoldering day has the same fire ID. Must be less than 15 characters.
strFacilityRegistryIdentifier	(Blank)		
strFacilityCategory	(Blank)		
strORISFacilityCode	(Blank)		
strSICPrimary	(Blank)		
strNAICSPrimary	NAICS	NA	Mandatory NIF field. Will be flagged by QC checker.
strFacilityName	Fire Name	GYPSUM CREEK	
strSiteDescription	Fire Type	wildfire	Either wildfire or prescribed.
strLocationAddress	Address	NA	Mandatory NIF field.
strCity	City	NA	Mandatory NIF field.
strState	State	AK	
strZipCode	ZipCode	NA	Mandatory NIF field. Will be flagged by QC checker
strCountry	Country	US	
strNTISiteID	(Blank)		
strDun&BradstreetNumber	(Blank)		
strTRIID	(Blank)		
strSubmittalFlag	Submittal Flag	A	"A" = "ADD" other options are delete or revise etc.
strTribalCode	Tribal Code	000	WRAP does not report tribal code but required data field in NIF format "000" = "not used"

Table B-3: WRAP NIF 3.0 for Fire – Emission Unit Record

EPA NIF Field	WRAP NIF Fire Field	Example Value	Comment
strRecordType	Record Type	EU	EU for every record
strStateCountyFIPs	FIPS	02110	
strStateFacilityIdentifier	Fire ID	AK-WF-229-1	Fire ID must be unique for every flaming fire day. Every corresponding smoldering day has the same fire ID. Must be less than 15 characters.
strEmissionUnitID	EU ID (F or S)	F	Either F or S indicating a flaming or a smoldering fire day No two entries may have the same Fire ID and EU ID
strORISBoilerID	(Blank)		
strSICUnitLevel	(Blank)		
strNAICSUnitLevel	(Blank)		
strBlankField	(Blank)		
sngDesignCapacity	Area Burned	10	
strDesignCapacityUnitNumerator	Area Burned Unit	ACRE	
strDesignCapacityUnitDenominator	(Blank)		
sngMaxNameplateCapacity	(Blank)		
strEmissionUnitDescription	(Blank)		
strSubmittalFlag	Submittal Flag	A	"A" = "ADD" other options are delete or revise, etc.
strTribalCode	Tribal Code	000	WRAP does not report tribal code but required data field in NIF format "000" = "not used"

Table B-4: WRAP NIF 3.0 for Fire - Emission Process Record

EPA NIF Field	WRAP NIF Fire Field	Example Value	Comment
strRecordType	Record Type	EP	EP for every record
strStateCountyFIPS	FIPS	02110	
strStateFacilityIdentifier	Fire ID	AK-WF-229-1	Fire ID must be unique for every flaming fire day. Every corresponding smoldering day has the same fire ID. Must be less than 15 characters.
strEmissionUnitID	EU ID (F or S)	F	Either F or S indicating a flaming or a smoldering fire day
strEmissionReleasePointID	Release Point ID	F H1	Used to relate the entries in the "EP" record to entries in the "ER" record. A single entry in the ER record exists for every EP record. One for every hour of every fire day (both smolder and flaming fire days).
strProcessID	Hour ID	H1	Hourly designation. No two records may have the same Fire, EU and Hour ID.
strSCC	SCC	2810001000	
strProcessMACTCode	(Blank)		
strEmissionProcessDescription	NFDRS	A	
intWinterThroughputPCT	(Blank)		
intSpringThroughputPCT	(Blank)		
intSummerThroughputPCT	(Blank)		
intFallThroughputPCT	(Blank)		
intAnnualAvgDaysPerWeek	(Blank)		
intAnnualAvgWeeksPerYear	(Blank)		
intAnnualAvgHoursPerDay	(Blank)		
IntAnnualAvgHoursPerYear	(Blank)		
sngHeatContent	Fuel Loading	0.50	
sngSulfurContent	(Blank)		
sngAshContent	(Blank)		
strProcessMACTComplianceStatus	(Blank)		
strSubmittalFlag	Submittal Flag	A	"A" = "ADD" other options are delete or revise etc.
strTribalCode	Tribal Code	000	WRAP does not report tribal code but required data field in NIF format "000" = "not used"

Table B-5: WRAP NIF 3.0 for Fire - Emission Release Point Record

EPA NIF Field	WRAP NIF Fire Field	Example Value	Comment
strRecordType	ER	ER	ER for every record
strStateCountyFIPs	FIPS	02110	
strStateFacilityIdentifier	Fire ID	AK-WF-229-1	Fire ID must be unique for every flaming fire day. Every corresponding smoldering day has the same fire ID. Must be less than 15 characters.
strBlankField	(Blank)		
strEmissionReleasePointID	ER ID	F H1	Used to relate the entries in the "EP" record to entries in the "ER" record. A single entry in the ER record exists for every EP record. One for every hour of every fire day (both smolder and flaming fire days).
strEmissionReleasePointType	ER Point Type	05	
strBlankField2	(Blank)		
sngStackHeight	plume top	0.023040	
sngStackDiameter	plume bottom	0.000000	
sngStackFencelineDistance	percent first layer	0.469300	
sngExitGasTemperature	(Blank)		
sngExitGasVelocity	(Blank)		
sngExitGasFlowRate	(Blank)		
dblXCoordinate	X Position	-134.977493	
dblYCoordinate	Y Position	58.909443	
intUTMZone	(Blank)		Not required for LATLON
strXYCoordinateType	Coordinate Type	LATLON	
IngHorizontalAreaFugitive	(Blank)		
IngReleaseHeightFugitive	(Blank)		
strFugitiveDimensionsUnit	(Blank)		
strEmissionsReleasePtDescription	ER record Description	Hour1	
strSubmittalFlag	Submittal Flag	A	"A" = "ADD" other options are delete or revise etc.
strHorizontalCollectionMethodCode	Collection Method	027	"027" = "The information is not known"
strHorizontalAccuracyMeasure	Horizontal Accuracy	0	No accuracy data available
strHorizontalReferenceDatumCode	Horizontal Reference	NA	Mandatory field. NA will be flagged by QC checker.
strReferencePointCode	Reference Point	108	"108" = point not included in Code Tables
strSourceMapScaleNumber	(Blank)		
strCoordinateDataSourceCode	(Blank)		
strTribalCode	Tribal Code	000	WRAP does not report tribal code but required data field in NIF format "000" = "not used"

Table B-6: WRAP NIF 3.0 for Fire - Emission Period Record

EPA NIF Field	WRAP NIF Fire Field	Example Value	Comment
strRecordType	Record Type	PE	PE for every record
strStateCountyFIPs	FIPS	02110	
strStateFacilityIdentifier	Fire ID	AK-WF-229-1	Fire ID must be unique for every flaming fire day. Every corresponding smoldering day has the same fire ID. Must be less than 15 characters.
strEmissionUnitID	EU ID (F or S)	F	Either F or S indicating a flaming or a smoldering fire day
strProcessID	Hour ID	H1	Hourly designation. No two records may have the same Fire, EU and Hour ID.
IngStartDate	Start Date	20020424	Since fire records are daily, StartDate=EndDate and there are the same # of records in the this table as there are in the ER and EP records. Taken From DateSlash Field of GISOUT
IngEndDate	End Date	20020424	
strBlankField	(Blank)		
intStartTime	Start Time	0000	
intEndTime	End Time	0059	
strBlankField2	(Blank)		
sngActualThroughput	Area Burned/Hour	0.0570	Acres Burned times temporal burn factor
strThroughputUnitNumerator	Area Unit	ACRE	
intMaterial	Material Burned	936	Many options are available such as wood & wood/bark. "936" is vegetation which is what LADCO was reporting
strMaterialIO	Material Input/Output	I	
intPeriodDaysPerWeek	(Blank)		
intPeriodWeeksPerPeriod	(Blank)		
intPeriodHoursPerDays	(Blank)		
intPeriodHoursPerPeriod	(Blank)		
strSubmittalFlag	Submittal Flag	A	"A" = "ADD" other options are delete or revise etc.
strTribalCode	Tribal Code	000	WRAP does not report tribal code but required data field in NIF format "000" = "not used"

Table B-7: WRAP NIF 3.0 for Fire - Control Record

EPA NIF Field	WRAP NIF Fire Field	Example Value	Comment
strRecordType	Record Type	CE	CE for every record
strStateCountyFIPs	FIPS	02110	
strStateFacilityIdentifier	Fire ID	AK-WF-229-1	Fire ID must be unique for every flaming fire day. Every corresponding smoldering day has the same fire ID. Must be less than 15 characters.
strEmissionUnitID	EU ID (F or S)	F	Either F or S indicating a flaming or a smoldering fire day
strProcessID	Hour ID	H1	Hourly designation. No two records may have the same Fire, EU and Hour ID.
strPollutantCode	Pollutant Code	PM10-PRI	Some pollutants like EC OC and CH4 aren't in the table POLLUTANT_CODES but are in the POLLUTANT_CATEGORIES both of which are NIF standard code tables
strBlankField	(Blank)		
sngPrimaryPCTControlEfficiency	(Blank)		
sngPCTCaptureEfficiency	(Blank)		
sngTotalCaptureControlEfficiency	(Blank)		
strPrimaryDeviceTypeCode	Primary Device Type Code	000	Mandatory Field "000" = "uncontrolled"
strSecondaryDeviceTypeCode	(Blank)		
strBlankField2	(Blank)		
strControlSystemDescription	(Blank)		
strThirdControlDeviceTypeCode	(Blank)		
strFourthControlDeviceTypeCode	(Blank)		
strSubmittalFlag	Submittal Flag	A	"A" = "ADD" other options are delete or revise etc.
strTribalCode	Tribal Code	000	WRAP does not report tribal code but required data field in NIF format "000" = "not used"

Table B-8: WRAP NIF 3.0 for Fire - Emission Record

EPA NIF Field	WRAP NIF Fire Field	Example Value	Comment
strRecordType	Record Type	EM	EM for every record
strStateCountyFIPs	FIPS	02110	
strStateFacilityIdentifier	Fire ID	AK-WF-229-1	Fire ID must be unique for every flaming fire day. Every corresponding smoldering day has the same fire ID. Must be less than 15 characters.
strEmissionUnitID	EU ID (F or S)	F	Either F or S indicating a flaming or a smoldering fire day
strProcessID	Hour ID	H1	Hourly designation. No two records may have the same Fire, EU and Hour ID.
strPollutantCode	Pollutant Code	PM10-PRI	Some pollutants like EC OC and CH4 aren't in the table POLLUTANT_CODES but are in the POLLUTANT_CATEGORIES both of which are NIF standard code tables
strBlankField	(Blank)		
strEmissionReleasePointID	ER ID	F H01	
lngStartDate	Start Date	20020424	
lngEndDate	End Date	20020424	
intStartTime	Start Time	0000	
intEndTime	End Time	0059	
strBlankField2	(Blank)		
dblEmissionNumericValue	Hourly Emissions	0.0004014	
strEmissionUnitNumerator	Unit	TON	
strEmissionType	Emission Type	30	
sngEMReliabilityIndicator	(Blank)		
sngFactorNumericValue	Emission Factor	28.10	
strFactorUnitNumerator	Emission Factor Numerator	LB	
strFactorUnitDenominator	Emission Factor Denominator	TON	
intMaterial	Material Burned	936	Many options are available such as wood & wood/bark. "936" is vegetation which is what LADCO was reporting
strMaterialIO	Material Input/Output	I	
strBlankField3	(Blank)		
strEmissionCalculationMethodCode	(Blank)		
strEFReliabilityIndicator	(Blank)		
sngRuleEffectiveness	(Blank)		
strRuleEffectivenessMethod	(Blank)		
strBlankField4	(Blank)		
strHAPEmissionsPerformanceLevel	(Blank)		
strControlStatus	(Blank)		
strEmissionDataLevel	(Blank)		
strSubmittalFlag	Submittal Flag	A	"A" = "ADD" other options are delete or revise etc.
strTribalCode	Tribal Code	000	WRAP does not report tribal code but required data field in NIF format "000" = "not used"